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A GUIDE

TO THE

PRACTICAL EXAMINATION

OF

URINE.

FOR THE USE OF PHYSICIANS AND STUDENTS.

BY

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WITH A PLATE AND NUMEROUS ILLUSTRATIONS.

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PREFACE.

DOUBTLESS it will be thought by some that there is no present necessity for an additional volume on the subject which the title of this pretends to cover. Such was, indeed, the writer's own impression, when urged, a few months ago, to prepare it. Some reflection, however, convinced him that, while there were quite a number of comprehensive works of great value, and a smaller number of manuals or guides for the examination of urine, the latter seemed altogether too limited, while the former are too bulky to be convenient for daily use. It was further thought that an experience of several years in almost daily microscopical and chemical examinations of urine for others and himself, as well as in teaching the subject in the University of Pennsylvania, had given the author such familiarity with the practical wants of the physician, as would appear to justify his attempting to supply them in a convenient shape.

Pains have been taken to secure a completeness of illustration not usual in the smaller works, while the methods for the most exact quantitative, as well as ap-

proximate analysis, have been included, without too much increasing the size of the volume.

The modes of approximate estimation so commonly used in the German laboratories, it is believed, are here published for the first time in English. For the details of these the writer is indebted to the admirable practical treatise of Hoffmann and Ultzmann, so often referred to in the text. To Messrs. Lindsay & Blakiston acknowledgment is due for the privilege of using electrotypes of certain cuts in the American edition of Dr. George Harley's work "On the Urine and its Derangements," and to Dr. C. B. Nancrede for assistance in drawing and coloring.

332 So. Fifteenth Street,
Nov. 1st, 1874.

LIST OF ILLUSTRATIONS.

PRACTICAL EXAMINATION OF THE URINE.

SECRETION OF URINE.

The theory which explains the secretion of urine most consistently with the facts, is one which, while it makes it mainly physical, admits something also of the nature of elaboration in the acts of the kidney. Nothing can be more beautiful at first thought than the theory of Ludwig, according to whom the process is a purely physical one—partly a transudation and partly a diffusion or osmosis. He correctly states that in the capillaries of the malpighian bodies, there is a greatly increased blood pressure caused by the resistance to the exit of the blood through the efferent vessel. As the result of this, a transudation of the watery constituents of the blood, with some dissolved salts, takes place into the malpighian capsule. Thus the blood is greatly thickened when it reaches the second capillary system surrounding the convoluted tubules which contain the thin aqueous transudation from the malpighian bodies. Here we have then, the essential elements of a complete osmometer,—

an animal membrane in the thin wall of the capillary and the delicate basement-membrane of the tubule, with a dense fluid (the blood) on one side, and a thin saline solution on the other. An interchange now takes place, as the result of which a current sets in, of the water from the tubules to the blood, and of the products of regressive metamorphosis, urea, etc., and salts to the tubules, concentrating the fluid in the latter, making it in other words urine; while the albuminous constituents of the blood are retained there, because of their well-known resistance to osmosis.

Two important facts, however, remain unaccounted for by this theory, beautifully simple as it is. These are, 1st, that if the tubules are stripped of their epithelium as they are in disease, urea and other products of regressive metamorphosis are no longer so freely removed; and 2d, that we can hardly account in this manner for the production of an acid fluid from an alkaline one, as is the case. We must therefore admit some elaborating action on the part of the epithelium through which these results are obtained. Doubtless, however, the larger proportion of the act is a physical one—a process of transudation or filtration and of diffusion or osmosis.*

* Since the above was written I have met (*Medical News and Library* for October, from the *London Lancet* of July 1st, 1874) the account of some experiments by Dr. Ralfe, in the laboratory of Charing Cross Hospital, London, which afford some expla-

REAGENTS AND APPARATUS REQUIRED FOR QUALITATIVE AND APPROXIMATE ANALYSIS.*

It is not a matter of very great importance in what form of bottle reagents are kept. They should hold enough—four ounces is a convenient quantity—and be provided with ground-glass stoppers for the acids, but the alkalies are better kept in bottles with rubber stoppers. Those required are as follows:

1. Pure colorless nitric acid (HNO_3).
2. Nitroso-nitric acid, the brown fuming nitrous acid of commerce, really nitric acid containing nitrogen tetroxide ($HNO_3+N_2O_4$ or NO_2).
3. Pure hydrochloric acid (HCl).
4. Pure colorless sulphuric acid (H_2SO_4).

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nation of this interesting phenomenon. He introduced an alkaline solution of sodium bicarbonate and neutral sodium phosphate in a small **U**-shaped tube, fitted with a diaphragm at the bend, and passed a weak electric current through the solution. In a short time the fluid in the limb connected with the positive pole became acid from the formation of acid sodium phosphate, the substance which is the chief agent in producing the acid reaction of the urine, while the fluid in the limb connected with the negative pole increased in alkalinity. The changes are represented by the following formula:

Sodium Bicarbonate.		Neutral Sodium Phosphate.		Sodium Carbonate.		Acid Sodium Phosphate.
$NaHCO_3$	+	Na_2HPO_4	=	Na_2CO_3	+	NaH_2PO_4

* All reagents and apparatus suitable for urinary analysis, may be obtained of Bullock & Crenshaw, 528 Arch Street, Philadelphia.

5. Pure acetic acid ($C_2H_4O_2$).
6. Liquor potassæ, U. S. P. The sp. gr. is 1065, and it contains $5\frac{8}{10}$ per cent. of potassium hydroxide (HKO).
7. Solution of caustic potash, 1 part to 2 of distilled water, sp. gr. 1330 +, to be spoken of in the text as the "stronger solution of potash."
8. Solution of barium chloride, 4 parts crystallized barium chloride, 16 of distilled water, and 1 of hydrochloric acid.
9. Liquor ammoniæ, U. S. P.
10. The magnesian fluid, containing of magnesium sulphate and pure ammonium chloride, each 1 part, distilled water 8 parts, and pure liquor ammoniæ 1 part.
11. Solution of copper sulphate, say 1 part to 4 of distilled water.
12. Pavy's or Fehling's copper solutions, made as directed under volumetric analysis for sugar.
13. Solution of silver nitrate, 1 part to 8 of distilled water.
14. Solution of lead acetate (sugar of lead), 1 part to 4 distilled water.
15. Solution of basic lead acetate, 1 part to 4 distilled water.
16. Distilled water, a litre or a quart.
17. Alcohol, 95 per cent. a half litre or a pint, and others as required.

Apparatus.

A note and drawing book.

1 dozen test-tubes, assorted sizes, some narrow, with test-tube rack and drainer. (Some test-tubes, with bases, so that they may stand on a shelf or mantel, are convenient and desirable; see Fig. 4.)

4 conical glasses. (Observe that they terminate in a point, and that there is not a convexity at the bottom.)

Red and blue litmus-paper; filtering-paper.

Urinometer and urinometer glass.

4 ground-glass covers, assorted sizes.

Spirit-lamp.

3 porcelain capsules.

4 beaker glasses, small and medium sizes.

½ dozen watch-glasses.

3 glass funnels.

Glass stirring-rods and dropping-tubes.

1 large receiving-glass to measure twenty-four hours' urine, with capacity of 2000 cubic centimetres or more.

1 graduated measuring-glass holding 500 c.c.

1 wash-bottle with distilled water.

1 retort stand; water bath.

1 or 2 sheet-iron tripods with wire gauze to cover.

1 100-minim pipette; 1 volume pipette for 5 c.c., another for 10 c.c.

Platinum spoon.

Blowpipe.

Swabs for cleaning test-tubes, etc.

A microscope with two object-glasses, a $\frac{1}{4}$ or $\frac{1}{5}$ inch, and a 1 inch or $\frac{8}{10}$ inch; stage micrometer; camera lucida for drawing; glass slides, thin covers, *shallow cells;* test-bottles with capillary stoppers; plain glass pipettes.

For volumetric analysis are required in addition,

A full set of volume pipettes, 5, 10, 15, 20, 30, 50 c.c.

1 graduated dropping pipette, 20 c.c.

2 burettes of 50 c.c. capacity.

A half litre flask.

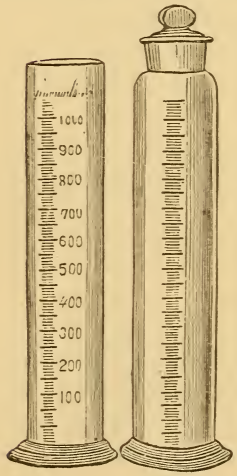
Volumetric solutions as directed under volumetric analysis.

If the solutions are made by the student himself, as they may be, he should be provided with a balance which will turn with the $\frac{1}{50}$th of a grain, or 1.3 milligrammes.

SELECTING A SPECIMEN OF URINE.

In obtaining a specimen of urine for examination, it should as far as possible, be a part of the whole twenty-four hours' urine, as the specific gravity, reaction, and other properties are well known to vary during the twenty-four hours, and the only accurate method is therefore to take a part of the total. But as this is not always possible, a portion of that passed in the morning before breakfast is generally most suitable. And yet this is not always the case. Thus, when a small quantity of albumen is present in urine, it is often increased after a meal, and sometimes when there is no trace apparent in the morning urine, a little will be found detectible after a meal. The same is true of sugar. In Fig. 1 are represented forms of glass vessels used for measuring large quantities of urine.

FIG. 1.



GENERAL PHYSICAL AND CHEMICAL CHARACTERS OF THE URINE.

Normal urine may be described as a transparent, aqueous fluid of a pale yellow (or amber) hue, acid reaction, specific gravity of about 1020 when passed in the average quantity of 1500 cubic centimetres (50 ounces) in the twenty-four hours, and possessing an odor which can only be described as "characteristic" or "urinous."

Each one of these characters is, however, liable to some variation within the limits of health, as well as disease, and with these variations we should be thoroughly familiar before interpreting a given specimen.

I. *As to Transparency.* This, although quite constant, can scarcely be considered an essential character of normal urine, while on the other hand, it by no means follows that because a given specimen of urine is transparent, it is therefore normal.

Causes of Diminished Transparency.—Diminished transparency may be due to one of three causes. 1. Even urine which is apparently perfectly transparent when passed, commonly exhibits a few minutes after standing, a faint cloud floating somewhere between the top and bottom, which is composed of *mucus* derived from the genito-urinary tract. Mucus itself is also transparent, but becomes visible through the presence of so-called

mucus-corpuscles and epithelium in different stages of growth, discoverable by microscopic examination. In the urine of females, this cloud is apt to be more distinctly visible in consequence of the increased amount of epithelium from the vagina, and general increased area of the mucus-surfaces in this sex. There is nothing abnormal in the presence of such an amount of mucus as is covered by the above description. The effect of alkalies, heat, and strong acids is to leave the appearance unchanged, but acetic acid *may* produce a slight increase of the opacity.

2. Normal acid urine may be partially opaque at the moment when passed by reason of the presence of the *earthy phosphates of lime and magnesia.* These shortly after passing begin to subside, and within half an hour present an appearance not unlike that of mucus—that of a flocculent mass floating somewhere between the top and bottom of the vessel. But still later, generally within an hour, it has approached the bottom and become a sediment, cloudy and bulky, but leaving a transparent supernatant fluid. The test of its nature is the addition of a few drops of any acid, as *acetic,* which will cause a prompt disappearance of the sediment, if it be the earthy phosphate, while the application of heat will increase it, such increase being also rapidly dissipated by the action of acid.

The more or less constant presence of the earthy phos-

phates above mentioned cannot be considered abnormal. Requiring an acid urine to keep them in solution, a diminution of the degree of this may result in their precipitation, which is further increased by an alkaline reaction. Such diminished acidity and substitution of alkalinity always takes place during digestion, and the deposit is therefore at such time commonly observed.

3. Urine is sometimes rendered turbid by the presence of the so-called mixed *urates* of soda, potash, lime, and magnesia. The most frequent cause of this precipitation in normal urine, is a reduction in the temperature of the urine after being passed. Although highly soluble in water at the temperature of the body, the urates are promptly precipitated from a cold urine, such as would be found in a room without fire of a winter's morning.

As in the case of earthy phosphates, such opacity soon diminishes by subsidence of the disseminated urates, which become a white or pink *deposit*, occupying less bulk than phosphates. The test of its nature is the application of heat, which quickly causes its dissipation, while a deposit of phosphates is increased by heat.

Pathologically, urine may be opaque or semi-opaque from abnormal degrees of the above conditions, or from the presence of *pus*, which also subsides with a rapidity inversely as the quantity of mucus. If the latter is absent or present in small quantity, the subsidence is rapid; if, on the other hand, it is large, subsidence is slow, often

requiring several hours. The opacity of such urine is *increased* by the application of heat and acids, in consequence of the precipitation of the albumen which is always a constituent of *liquor puris.*

II. As to *consistence.* In health, urine is never anything else but aqueous, that is, dropping and flowing readily.

Pathologically, it often becomes viscid, glutinous, and with difficulty, or not at all, separable into drops. Such state may be due to the presence of an excess of pure mucus, but most frequently it is caused by the action upon pus of an alkalinity due to the presence of ammonium carbonate, to be again alluded to.

In the so-called chylous urine of tropical countries, also sometimes met here, there is an addition of molecular fat, giving a chylous appearance to the urine, and an increased consistence.

III. As to *color.* While normal urine may be characterized in general terms as *pale yellow,* or *amber hued,* there may be considerable variation in health. Due to the presence in solution of the normal coloring matters, it is deeper or paler according to the proportion of water dissolving them. After copious libations of beer or water, the quantity of urine discharged being large, the color is very pale. On the other hand, circumstances which diminish the proportion of water within the limits of health deepen the color. The complemental relation of the skin and kidneys is well known. In warm weather,

therefore, when the skin is acting freely, the quantity of urine is smaller, and it is darker. In winter the quantity is larger, and its color less deep. In persons from whom the respiratory exhalation is less, the urine is likewise less abundant, darker, and *vice versa.*

Pathologically, the color of urine may be altered by increase or diminution of the normal coloring matters, or by the addition of abnormal ones.

1. The former is also generally due to a change in the proportion of the coloring matters to the watery constituents. Thus we have almost an absence of color in the copious urines of diabetes, hysteria, and convulsions, while we have a high color in the urine of fevers and febrile states, chiefly because the quantity of water is diminished, but in the latter instance also because of the addition of an abnormal coloring matter, the *uroerythrin* of Heller.

2. The addition of abnormal coloring matters is seen in the instance just mentioned (fevers), in bloody urines, in urines containing the coloring matter of bile, in the *blue* and *brown* urines, of which several instances have been reported.

3. The urine is also colored after the ingestion of certain vegetable matters eliminated by the kidneys, as santonin, which gives a yellow color to urine.

IV. The *reaction* of normal *mixed* urine, that is, the urine of the entire twenty-four hours, is always acid. And generally, specimens of urine passed at any time of day

exhibit this reaction, though there is a difference in its intensity, while after a meal the urine may become neutral or even alkaline.

The cause of this change in the reaction is still disputed. Roberts believes that it is due to an admixture with the blood, of the elements of food, which are largely alkaline, and that the resulting increased alkalinity affects the reaction of the urine secreted. Bence Jones contends, that it is the demand made on the blood for the elements of the acid gastric juice, which thus affects the reaction of the urine secreted during digestion. While neither explanation is altogether satisfactory, the former seems more likely to be correct.

The cause of the acid reaction of the urine is usually ascribed to *acid sodic phosphate*, though it is probably also contributed to by other acid constituents, as *uric* and *hippuric* acids, and under certain circumstances, also by lactic and acetic acids.

There is often observed in urine which has been standing for a short time an increased degree of acidity, which sometimes results in a decomposition of urates, and a precipitation, first of acid urates, and then of uric acid. This has been ascribed to what has been called the *acid* fermentation, in which it is thought that lactic and acetic acids are formed in the decomposition of certain organic matters. This has not been altogether

satisfactorily proven, while the increased acidity is by no means constant.

It is certain, however, that acid urine which has stood for some time, and more rapidly in hot weather, exhibits an ammoniacal odor, and becomes alkaline in its reaction; attending this change of reaction results a semi-opacity with a precipitation of a white amorphous and crystalline sediment, and often also with the formation of an iridescent pellicle on the surface. The cause of these changes has been well determined, and has already been alluded to. Through the action of mucus and other organic matters acting in their decomposition as a *ferment*, the urea is converted into ammonium carbonate by the addition of two equivalents of water. Thus:

$$CH_4N_2O + 2H_2O = (NH_4)_2CO_3,$$

which gives the odor of ammonia and the alkaline reaction.

The opacity and deposits are due to the precipitation of the crystalline triple phosphate of ammonium and magnesium, the amorphous phosphate of lime, urate of ammonium, and to living vegetable organisms known as bacteria.

V. The *specific gravity* as stated may be put down at 1020 for an average amount of 1500 c. c. (50 oz.) in the twenty-four hours. But as this amount is by no means

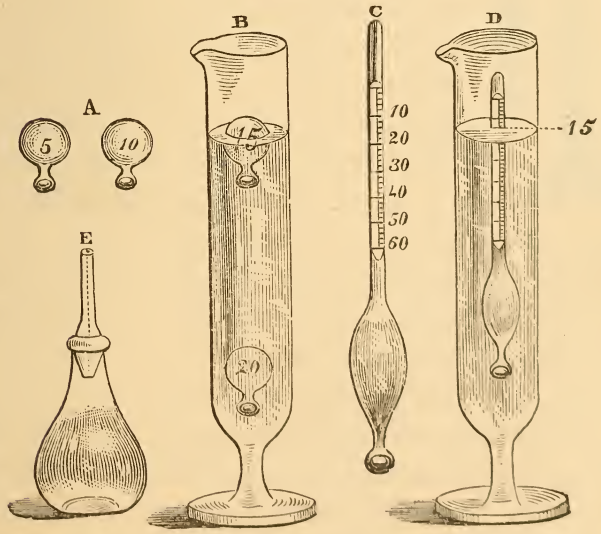
fixed, while the amount of solid matter remains about the same, the specific gravity must vary accordingly. In cold weather, when the skin is not acting, and after copious use of water and diuretics, the specific gravity may descend to 1005 within the limits of health. But, where perspiration is copious, or a drain of water from the economy takes place through some other channel, the urine becomes concentrated, and may be 1028 or more in specific gravity.

Pathologically, the specific gravity of urine is increased or diminished, but no results can be relied upon, unless they be based upon a consideration of the entire quantity passed in the twenty-four hours. The specific gravity is increased in *diabetes mellitus*, where it sometimes reaches 1050. A specific gravity of more than 1028, if it attend a copious urine, should excite suspicion of diabetes, and calls for sugar tests. The specific gravity is also increased in the first stage of the *acute fevers*, in consequence of the increased amount of solid matters excreted; and in the *first stage* of acute Bright's disease, from the presence of *blood*, the higher specific gravity of the latter raising that of the mixed fluid. The specific gravity is diminished in *hysterical* and *spasmodic* hydruria, though here it attends a proportionate increase of water and is not of much practical significance. In all forms of *Bright's disease*, except the stage of acute nephritis referred to, there is a tendency to lowering of

specific gravity from the diminished proportion of urea. Particularly is such reduction of specific gravity significant when it attends a diminished quantity of urine. In a general way, the presence of albumen and sugar being eliminated, variations in the specific gravity of urine point to variations in the amount of urea present; *lower specific gravity of mixed urine means less urea.*

To determine specific gravity, the so-called *urinometer* is almost invariably used, and though less accurate than the picnometer (E, Fig. 2) and balance, is still suffi-

FIG. 2. (From Harley.)

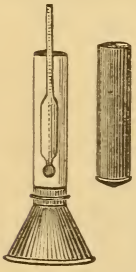


ciently so when carefully constructed. Every urinometer should first be tested with distilled water at 60° F.

(15.54 C.) into which it should sink to the mark 0 or 1000. In their graduation the lines indicating the degrees should gradually approach each other as the bulb is reached, because allowance must be made for the weight of the stem above water.

The English-made urinometers, about 5 inches long (Fig. 2 c), are generally accurate, but the short German instruments (3 inch) are very convenient for small quantities of urine. In the little urinometer of Heller (Fig. 3), much used in Vienna, in which the "sink" consists of leaden shot, the graduation of Baumé is retained, in which one degree corresponds with *seven* of the ordinary scale. Thus 1001 = 1007, 1002 = 1014, and so on. Especial care should be taken in testing these instruments, as a slight variation in them indicates a large one by the ordinary scale. The writer has in his possession an instrument of this kind which recorded the specific gravity of a given specimen of urine 1004, that is, 1029 by the ordinary scale, of which the specific gravity by a long-tried English instrument was found to be 1019. And on testing the former with distilled water, it was found to sink, not to 1000, but to 1001+, proving its inaccuracy. More recently a urinometer has been furnished in Vienna even slightly shorter than the original of Heller, in which the ordinary scale is re-

Fig. 3.



tained on an ivory stem within the tube, and the "sink" contains mercury instead of shot, apparently altogether more carefully made. These, so far as I have tried them, I have found accurate.

The cylindrical glass vessel usually supplied with the urinometer, or a sufficiently large test-tube, should be $\frac{3}{4}$ or $\frac{4}{5}$ filled, the urinometer introduced, and when at rest, the specific gravity read off. The cylinder or test-tube should not be too small in relation to the urinometer, lest in consequence of the capillary attraction between the latter and the walls of the cylinder, the urinometer should not sink as low as it ought. For the same reason the urinometer should not be allowed to impinge against one side of the glass. *If the quantity of urine be too small* sufficiently to fill the cylinder, it may be diluted with a quantity of distilled water sufficient to fill the cylinder to the required height. From the sp. gr. of this mixture may be calculated that of the urine. Thus suppose it is necessary to add four times as much water as urine to enable us to use the urinometer, that is, make five volumes, and the specific gravity of the mixed fluid is 1004, then that of the urine would be $1004 \times 5 = 1020$.

VI. *Quantity.* The average amount of urine in the twenty-four hours is put down at 1500 c. c., or about 50 fluid ounces. But enough has already been said to allow the inference that there is also much variation within the limits of health. All that has been said of color and

specific gravity in this respect is true of the quantity of urine, though in an inverse ratio. That is, in health, *diminished* intensity of color and *diminished* specific gravity correspond with *increased* quantity of urine. It is with regard to quantity that the complemental relation so well known to exist between the skin and kidneys most palpably shows itself, the increased action of the former causing diminished quantity of water separation by the latter, and *vice versa*. In deranged conditions, it is the absence of this relation of color and specific gravity to quantity which gives significance to either.

Pathologically. In *diabetes*, and hysterical and convulsive conditions, the quantity of urine is increased, in the former, however, with increased specific gravity, and in the latter with diminished. In *cardiac hypertrophy*, in common with all conditions of increased blood-pressure, in which we include ingestion of large amounts of water, the peripheral action of cold, etc., there is an increase of water, and a corresponding reduction in specific gravity and color.

In all forms of Bright's disease, except in the cirrhotic and albuminoid kidneys, there is a *tendency* to diminished secretion of urine. Towards the fatal termination, however, it is observed even in these affections. Any marked diminution of urine in these affections, particularly if it

be attended by a low specific gravity, which means diminished urea, becomes a portentous symptom.

In acute fevers and inflammatory affections, the quantity of urine is very constantly diminished until convalescence sets in, when there is generally observed a marked increase in the secretion of urine, which, in common with the profuse perspiration often observed at the same time, was long ago characterized by the word "critical."

VII. Of the *odor*, little more can be said than that it is "peculiar" or "characteristic" in health. There is, however, appreciable difference in its intensity, as most have observed in their own cases. Concentrated urines always exhibit what is described in common language as "strong odor." This is undoubtedly due to urea, though the peculiar odor of urine is not ascribed to urea, but rather to the minute quantities of phenylic, taurylic, and damoluric acid which are found in it.

Urine which has been standing exposed in warm weather, acquires an odor which is at once putrescent and ammoniacal, the former from decomposition of mucus and other organic matters, the latter from the ammonium carbonate derived from the urea. The former is predominant when a large amount of organic matter is present, and is often observed in destructive disease of the kidney or its pelvis, and especially of the bladder.

The odor of urine is very promptly influenced by that

of substances separated by the kidney from the blood, illustrated by the well-known phenomenon of the odor of violets in the urine of persons taking turpentine. The odor of cubebs, copaiba, and sandalwood oil is promptly communicated to the urine of persons taking them. So, too, the use of certain vegetable foods promptly influences the odor of the urine. Among these asparagus is prominent.

In *disease,* except the increased intensity of the characteristic odor in concentrated urines, the *putridity* alluded to, and a *sweetish* smell which often attends the presence of sugar in the urine, there seem to be no modifications of this "characteristic" odor of urine.

To Determine the amount of Solid Matters in the Twenty-four hours' Urine.

Knowing the quantity of urine passed in the twenty-four hours, and its specific gravity, an approximation to the quantity of solid matters, and thence that of water, may be readily obtained by multiplying the last two figures of the sp. gr., by what is known as Trapp's coefficient—2.33. This will give approximately the number of grammes. in the 1000 c. c. ($33\frac{1}{3}$ oz.).

Thus, suppose the twenty-four hours' urine to be 1200 c. c., and the sp. gr. to be 1022, then

$$22 \times 2.33 = 51.26 \text{ grms. in } 1000 \text{ c. c.}$$

But the total quantity of urine in twenty-four hours is 1200 c. c., therefore it will contain more than 1000 c. c. contain. Hence,

$$1000 : 1200 : : 51.26 : x = \frac{51.26 \times 1200}{1000} = 61.51 \text{ gms. (948.09 grs.)}$$

Now the normal amount of solid matters in the twenty-four hours is about 70 grammes (1080.1 grs.), showing that in this instance rather less than the normal quantity was separated. In this manner valuable information bearing upon diagnosis and prognosis may be obtained in a few seconds. The most striking variations are observed in diabetes and Bright's disease, the former of increase in solids by addition of sugar, the latter in diminution by loss of urea.

While this method of arriving at the solids is not sufficiently accurate for scientific use, it answers for ordinary clinical purposes.

THE STUDY OF THE DIFFERENT CONSTITUENTS OF URINE IN HEALTH AND DISEASE.

In the examination of a specimen of urine, the following are the steps which will be found most convenient in actual practice. Observe:

I. The quantity passed in twenty-four hours.
II. Color and transparency.
III. Odor.
IV. Reaction.
V. Specific gravity.
VI. Presence or absence of sediment, its quantity, and characters.

In all cases, whether the sediment be appreciable or not, a portion of the fluid should be set aside in a conical glass vessel for twelve hours, with a view to collecting the sediment for *microscopical* examination. The remaining, or supernatant fluid, *filtered, if necessary*, should then be further examined.

Organic Constituents.

VII. Presence or absence of albumen.
VIII. Presence or absence of sugar.
IX. Coloring matters. { Normal. / Abnormal.

These three are made to precede normal constituents, because they must form a part of *every* examination.

X. The biliary acids.
XI. Leucin and tyrosin.
XII. Urea.
XIII. Uric acid.

Inorganic Constituents.

XIV. Chlorides.
XV. Phosphates. { *a.* Earthy phosphates. *b.* Alkaline "
XVI. Sulphates.

Examination of Sediment Microscopically and Chemically.

I. Unorganized deposits, including crystals and amorphous deposits.

II. Organized deposits, including anatomical elements, such as casts, epithelium, pus, blood-corpuscles, etc.

III. Other morphological elements, as fungi, pigmentary particles, granular matter, extraneous substances, etc.

Nos. I, II, III, IV, V, VI require no further explanation than is involved in the consideration of the "general physical and chemical characters."

Organic Constituents.

VII. To Detect the Presence of Albumen. In all instances where the urine used for testing is not perfectly clear, it should be filtered before applying the tests. This may be done in a few minutes by means of filtering-paper and a funnel.

a. *The test by Heat.* A test-tube is filled to $\frac{1}{4}$ to $\frac{1}{3}$ its depth with clear urine, to which, if it be not of distinctly acid reaction, a few drops of acetic acid are added, and the fluid boiled over a spirit-lamp. If an opacity result, the slightest degree of which becomes visible in a clear urine held in a beam of sunlight, it is due either to *albumen* or *earthy phosphates.* If the latter, it promptly disappears on the addition of a few drops of nitric acid; if *albumen, it is permanent.* If further confirmation is desired, to the boiling urine quickly add half as much of the stronger potash solution (7, p. 16), when the albumen is dissolved, and the earthy phosphates again separate in flocculi.

If the urine has not been filtered, and is opaque from the presence of amorphous urates, the first effect of the application of heat is to clear up the fluid, and as the temperature is increased, the albumen, if present, is precipitated.

Acetic acid is preferred to nitric for acidulating the

urine, because if the quantity of albumen is small it may hold it in solution by nitric acid.

b. *The Nitric Acid test* is best applied according to Heller's method. Fill a test-tube to the depth of $1\frac{1}{2}$ to 2 inches with clear urine (for this purpose one of the test-tubes with a foot, Fig. 4, is most convenient), and allow about $\dot{3}$ c. c., or f$\mathfrak{Z}$ss. to f$\mathfrak{Z}$j of pure colorless nitric acid to trickle down the side of the inclined glass to the bottom, so as to underlie the urine.

FIG. 4.

FIG. 5.

If albumen is present, there appears at the point of contact, between the urine and nitric acid, *a sharp white band or zone* of varying thickness, according to the quantity of albumen present.

Precautions. 1. Much difficulty is often experienced in permitting the acid to flow from the pipette sufficiently slowly—that is, it will either not flow at all, or the finger in the effort to attain it is suddenly raised so much as to permit a sudden flow of the acid into the urine, which interferes with the success of the test. This difficulty is readily overcome by rotating the pipette covered by the end of the index-finger, between the middle finger and the thumb, whereby the flow may be easily controlled.

2. A somewhat similar white zone is formed by the ac-

tion of nitric acid on the mixed urates if present in excess, by which the more insoluble acid urates are thrown down. This zone might be mistaken for that of albumen; but the acid urates begin to appear, not so much at the border between the urine and acid as higher up; nor is the zone on the upper surface so sharply defined, but more irregular. By Hoffmann and Ultzmann the appearance is compared to the "cloudlike curling of rising smoke." Further, this layer if caused by urates is easily dissipated on the application of heat, although some care is necessary in this application lest in ebullition the ring be commingled with the entire mass of fluid and thus lost to view, although not actually dissolved. After some hours have elapsed these amorphous acid urates are completely decomposed by a further action of the nitric acid, and uric acid is then deposited as a characteristic crystalline sediment. When large quantities of albumen are present, there is never any difficulty with either test, but for small amounts of albumen this form of nitric acid test has proved in my hands by far the most delicate, quantities of albumen so small as to be altogether inappreciable by the heat test, being distinctly demonstrated.

3. This method obviates the possibility of two further sources of error pointed out by Bence Jones, first, that if albuminous urine be acidified by a small quantity of acid, as a drop or two, no precipitation of albumen takes place, while if too large a quantity as an equal bulk of acid be

added, the mixture in like manner remains perfectly clear. Roberts says he has known the latter fallacy to cause the concealment of albumen in the urine for months in a case of Bright's disease.

4. Occasionally, also, it happens that a urine is so highly concentrated—so highly charged with urea—that the simple addition of nitric acid causes a precipitation of crystals of nitrate of urea. But these are readily distinguished from albumen by their solubility by heat, and by their appearance under the microscope, which exhibits them made up of six-sided rhombic tablets. Such urine is always of high specific gravity.

5. If carbonic acid be abundantly present in urine, either free, or combined with ammonia as in the alkaline fermentation, or with soda or potash, during the administration of alkaline carbonates or salts of the vegetable acids, the addition of an acid liberates it with effervescence. Under ordinary circumstances, this does not interfere with the test; but if the quantity of carbonate of ammonia be *very* large, as is the case in some old urines, and the quantity of albumen small, the effervescence is so great as to make the nitric acid test impossible; while the amount of acetic acid required to secure an acidity sufficient to permit the use of the heat test may be so great as to completely hold in solution the small quantity of albumen. Such difficulty is further increased by the fact that these alkaline urines are always more or less

cloudy, and cannot be cleared up by ordinary filtration. Under these circumstances, boil the urine with a fourth part of its volume of the stronger solution of caustic potash, and filter. If the filtrate is still not quite clear, add one or two drops of the magnesian fluid; warm again, and filter. The fluid is then always clear and transparent, and, after being carefully acidulated with acetic acid, will show the smallest trace of albumen. But it can be made even more apparent; if to the fluid acidulated with acetic acid, a few drops of a solution of yellow prussiate of potash be added, the mixture shaken and allowed to stand for a few minutes, white flakes of separated albumen will soon be seen at the bottom (Hoffmann and Ultzmann).

When nitric acid is thus allowed to underlie normal urine, there appears between the urine and the acid a *brown* ring which grows in intensity on standing, and is due to the action of the acid on the coloring matters. In consequence of this fact, when the urine is highly charged with coloring matters, as it often is in fever cases, the albumen precipitated at the same place is similarly tinted. If there is much indican present in the urine, a rose-red or violet tint may be communicated to the albumen; if much blood-coloring matter, a brownish-red, and if undecomposed biliary coloring matters, a green hue.

Other Tests for Albumen. Nothing is said of the numerous other tests for albumen, such as carbolic acid, picric

acid, corrosive sublimate, sulphate of copper, alcohol, etc., because they are either inapplicable, or less accurate than the methods described. With regard to picric acid, however, which has been most recently lauded, I have experimentally determined that the heat and nitric acid tests show smaller quantities of albumen in urine than it does, while my friend, Prof. H. P. Bowditch of Boston, has arrived at the same results, by experimenting with carefully prepared solutions of egg albumen of known strength.*

Quantitative Estimation of Albumen. It is a matter of extreme importance in the course of Bright's disease that we should be able to compare the quantity of albumen contained in the urine from day to day. The only accurate method is by precipitation by acetic acid and boiling, separation by filtration, drying and weighing by delicately accurate balances, the weight of the filter having been previously determined. This, however, involves too much time for the busy practitioner, and we must fall back on one of the approximative methods. The best known of

* The method of using picric acid is to make a saturated watery solution (water takes up a very small quantity), place some urine in a test-tube, and allow the picric acid solution to fall into it drop by drop, when each drop as it passes through the urine is followed by an opaque white cloud. The test is very striking and beautiful, when the quantity of albumen is sufficient to permit its application. See note at end of volume.

these is to boil a given quantity of urine in a test-tube, add a few drops of nitric acid, and stand aside for twenty-four hours. The proportion of bulk occupied—one-fourth, one-eighth, a trace, etc., is used to indicate the quantity of albumen. Greater accuracy is obtained by previously filtering the urine of urates, epithelium or extraneous matter which may unduly increase the bulk of deposit on standing.

More definite but perhaps scarcely more accurate is the approximative quantitative estimation by means of Heller's nitric acid method as given by Hoffmann and Ultzmann. According to them, if the white zone of albumen has the depth of a crow-quill, is delicate and faintly white in color, has no granular appearance, and appears clearly defined only when placed against a dark background, the quantity is *less than half of one per cent.* If, however, the zone of albumen appears granular and flocculent, and sinks in more or less lumpy masses to the bottom, and when by stirring the albumen by means of a glass rod the mixture assumes the consistence and appearance of sour cream, then the quantity is very large, *one to two per cent.*

VIII. To Detect the Presence of Sugar. Of the large number of tests extant for the presence of sugar, only those are given which have borne the trial of experience, and it is suggested that for practical purposes the student should select some one of these, and

accustom himself to its use and the modifications in results to which all are more or less subject. I am confident that much of the difference of opinion with regard to the reliability of the different tests is due to the fact, that those claiming it have had more experience with the particular test which they recommend. Thus, in Germany, Moore's test is evidently the favorite one, while in my own hands, the old Trommer's test gives most satisfaction, simply because I have become accustomed to its use. But it is necessary to be familiar with more than one test, because cases of doubt constantly arise where the evidence of one is insufficient. Although Brücke has shown that sugar is present in very minute quantity in normal urines, yet the amount is so slight as to escape detection by the ordinary tests.

Specific Gravity and Quantity as a test. The specific gravity alone, when 1030 or more, affords a presumption of the presence of sugar, and if at the same time the urine is very pale, and far exceeds 1500 c. c. (50 fl. oz.) in twenty-four hours, the probabilities are much increased. These facts at least call for the use of other tests to determine the question. Further, if the quantity of sugar is very large, a sweetish odor and taste is communicated to the urine.

In using any of the following tests, if albumen is at all abundantly present, it should first be removed by boiling and filtration.

Moore's Test. Moore's test depends upon the fact that grape-sugar, with which diabetic sugar is identical, undergoes decomposition by boiling in contact with caustic alkali. To a small quantity of urine in a test-tube, add half as much liquor potassa or liquor soda and boil. If sugar is present, a yellowish-brown color will soon make its appearance, which becomes more intense as the boiling is continued, and which will be the deeper the larger the proportion of sugar, becoming finally almost black if the quantity is very large. The coloration is due to the formation, first, of glucic, and finally of melassic acid, which, however, remain in solution. The flaky precipitate which is observed after the addition of the alkali, and is increased on the application of heat, is made up of the earthy phosphates, which may be filtered off before the heat is applied if very abundant.

If now to the colored fluid a few drops of nitric acid be added, the brown coloration disappears, and the odor of burnt molasses is developed, and in this we have Heller's modification of Moore's test.

Precautions. 1. Solutions of soda and potash are liable to become impregnated with lead, either from being kept in flint-glass bottles, or from the glazed earthenware vessels in which, during preparation, they are evaporated. Such contamination always causes the production of a brown and black color when boiled with organic matter containing sulphur, due to the

formation of sulphuret of lead. This error may be avoided by first ascertaining the purity of the alkaline solutions, and afterwards keeping them in green glass bottles.

2. If the urine exhibits already a high color, which is, however, very rare with diabetic urines, the coloring matters may be precipitated by solution of acetate (sugar) of lead, which does not at all interfere with the sugar, although the *sub*acetate of lead throws down also a small quantity of sugar.

3. The coloring matters of bile in urine, either when pure, or decomposed (that is, when they respond neither to Gmelin's or Heller's test), produce a *brown* color with liquor potassa or soda *without the application of heat.*

4. According to Bædecker, a substance is sometimes found in urine which he calls *alkapton*, which when strong solutions of alkali are added produces a brown discoloration from above downward. This, according to him, also reduces the salts of copper, but does not affect the bismuth salts.

The Copper Tests.—Trommer's test. The copper tests depend upon the power which grape-sugar possesses of reducing the oxide of copper in common with other metallic oxides, as silver, gold, etc., to a lower state of oxidation.

In *Trommer's test*, the oxide of copper is set free at the

time of its application by liquor potassæ or sodæ in excess. A drop or two of a solution of cupric sulphate of almost any strength (say 1 to 10), is added to the suspected urine, and then liquor potassæ or sodæ equal to half the total volume. On first adding the alkali there is immediately liberated, in addition to the earthy phosphates, a blue precipitate of hydrated cupric protoxide, *which, if sugar is present, is redissolved on adding more alkali*, producing a beautiful blue transparent liquid. If, on the other hand, no sugar is present, the fluid will not be thus blue after the addition of the copper and alkali, but exhibit rather a turbid greenish hue. This, however, is not alone relied upon, but the *mixture is boiled*, and if sugar is present, a copious yellow precipitate of *hydrated* cupric suboxide takes place, which subsequently loses its water and becomes the red suboxide, which soon forms a close adhesion to the bottom or sides of the test-tube.

Precautions. 1. Albumen, if present, must always be removed, as it interferes with the reduction of the copper.

2. While the fluid must be made to boil for perhaps half a minute, the precipitate should take place *without prolonged boiling*, as numerous organic substances other than sugar will reduce the salts of copper by prolonged boiling.

3. The flocculent precipitate of earthy phosphates

should not be mistaken for the suboxide of copper; it is either transparent or of a pale greenish hue. On the other hand, a mere change of color is not sufficient. There must be an actual yellow or red precipitate. If it be desired to eliminate this source of error altogether, it may be done by adding the potash solution, and filtering before adding the copper.

4. Carefully conducted experiments by Dr. Beale have shown that if the urine contain ammonium chloride (even in very small quantity), ammonium urate or other ammoniacal salts, the cupric suboxide will not be precipitated *if only a small quantity of sugar is present.* Under these circumstances, unless there be a considerable quantity of the above salts present, in which case the blue color will remain, the mixture will change to a brownish hue upon boiling, but *no opalescence* or *precipitate* of copper will occur. Prolonged boiling with potash, of urine containing ammonium compounds, will drive off the latter, which may be recognized by its characteristic fumes, after which the copper tests will again become operative for the smaller quantities of sugar. But under any circumstances such urine should be subjected to the bismuth or fermentation tests, or both.

Other Copper Test Solutions.—Fehling's and Pavy's fluids. It has been stated that when an alkali is added to a solution of sulphate of copper an abundant precipitate of hydrated cupric protoxide is thrown down. This is not

dissolved by any excess of alkali added, but if some organic matter is added or happens to be present, an excess of alkali dissolves the protoxide. It is for this reason, that if sugar happens to be present in a suspected fluid to which these have been added, the precipitated protoxide is dissolved and a clear blue fluid results.

These facts enable us to construct a fluid which will hold the protoxide of copper in solution; but in selecting an organic substance one must be chosen which will not reduce the oxide of copper as does sugar, else it will make our test inoperative. Such a substance is *tartaric acid*, which is usually employed.

Of the numerous test fluids employed, only Fehling's, and Dr. Pavy's modification of it, are given, since these are most convenient in practice, and serve also for quantitative estimation. The one or the other may be used, as it is preferred to work with the English or metric system.

Fehling's solution. 34.639 grammes (534.479 grains) pure crystallized sulphate of copper are dissolved in about 200 grammes (3086 grains) distilled water; 173 grammes (2669.39 grains) chemically pure crystallized neutral tartrate of soda in 500 to 600 grammes (7715 to 9258 grains), solution caustic soda of specific gravity 1.12, and pour little by little into this basic solution, the copper solution. The clear mixed fluid is diluted to 1 litre (2.1 pints).

10 c. c. (162 minims) of this solution will be reduced by .05 grammes, or 50 milligrammes (.7715 grains) diabetic sugar. If the copper solution is to be kept some time, it is absolutely essential that it should be placed in smaller (40–80 grammes) bottles, sealed and kept in the cellar.

Pavy's solution consists of

Cupric Sulphate, . . .	320 grains.
Neutral Potassic Tartrate, . .	640 grains.
Caustic Potash, ...	1280 grains.
Distilled Water, ...	20 fluid ounces.

The solution is made in the same manner as Fehling's, and 100 minims correspond to $\frac{1}{2}$ grain grape-sugar. These solutions serve equally well for qualitative and volumetric testing, but if it is simply desired to have a solution for the former purpose, it may be made by pounding together 5 grains (.324 grammes) cupric sulphate, 10 grains (.624 grammes) neutral potassic tartrate, and dissolving in 2 drachms (7.4 c. c.) liquor potassæ. The usual blue fluid results.

To use. In using either of the above solutions for qualitative testing, a small quantity should be placed in a test-tube and boiled alone for a few seconds, because the fluid, in course of time, decomposes, and as a result the copper is reduced, and a precipitate takes place by boiling it alone.

If this occurs, a new supply may be obtained, or a little more soda may be added, the fluid filtered, and it is again ready for use. After the solution is brought to boil, the suspected urine is added, drop by drop. If sugar is present in any quantity, the first few drops will usually cause the yellowish precipitate, but the dropping may be continued until an equal volume of urine is added, when the mixture is again brought to boil. If no precipitate occurs no sugar is present.

The same precautions laid down with regard to Trommer's test are here to be observed.

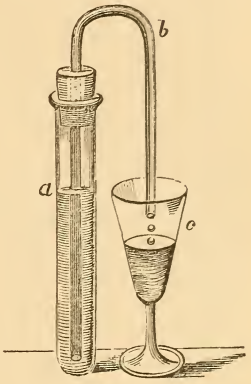
Bœtger's Bismuth test consists in the addition to urine in a test-tube of half its volume of liquor potassæ or sodæ, then of a pinch of the ordinary subnitrate of bismuth, shaking and boiling for a couple of minutes. The sugar possesses the power of reducing the salts of bismuth, and if sugar is present, the black metallic bismuth will shortly be deposited on the side of the test-tube. If the quantity of sugar is small, the bismuth will assume a grayish hue.

This is an excellent test, and the one I usually employ to confirm the results of the copper test. No other substance than sugar is supposed to reduce bismuth salts.

The Fermentation test. Perhaps the most reliable of all tests for the presence of sugar, is the fermentation test, but being somewhat troublesome, is less suitable to the practitioner as an everyday test. The most con-

venient method of its application is as follows: A test-tube of large size is provided with a tightly fitting perforated cork, through which one limb of a bent glass tube long enough to reach nearly to the bottom is passed. A small quantity of ordinary baker's or brewer's yeast (about a fluid drachm, or 3 to 4 c. c.) is placed in the tube, which is then filled with urine, tightly corked, allowing no air to remain, and placed in a vessel which may be filled with tepid water, in a moderately warm room. If sugar is present evidences of fermentation will soon present themselves in the formation of carbonic acid, which will force the fluid out of the bent tube into the glass, arranged for its reception. *If carefully performed this test is thoroughly reliable.*

FIG. 6. (From Harley.)



Quantitative Estimation of Sugar. So important is a knowledge of the daily change in the quantity of sugar in the urine of a case of diabetes, that it may be laid down that some kind of quantitative estimation from day to day is absolutely necessary.

1. *Approximative Estimation.* While the specific gravity determined from the twenty-four hours' urine may serve to give a general idea of the increase or diminution of

the amount of sugar, in consequence of the complex composition of the urine it cannot be relied upon even for approximate estimation, as it might be in a simple watery solution of sugar.

To those who habituate themselves to Moore's test, the method of Vogel recommends itself by its simplicity and brevity. As the result of trial, Vogel has determined that solutions of grape-sugar, when boiled with half their bulk of liquor potassæ, exhibit the following changes of color: A 1 *per cent.* solution becomes *canary yellow;* a 2 *per cent.* a *dark amber;* a 5 *per cent.* a *dark Jamaica rum* (?); and a 10 *per cent.* a *dark black-brown,* and *opaque,* while all solutions of a less percentage are more or less transparent.

With a pale urine, in the hands of one accustomed to this test, if the specific gravity be also regarded, tolerable accuracy may be obtained. It should certainly be employed rather than none at all.

b. *Roberts's Fermentation test* is based on the fact that diabetic urine loses in specific gravity after fermentation is completed. Dr. Roberts, of Manchester, England, has shown by careful experiments, that every "degree" in specific gravity lost in fermentation, corresponds to 1 *grain of sugar per fluid ounce.* Thus, if before fermentation the specific gravity of a given specimen is 1050, and after fermentation it is 1020, it will have contained 30 grains to the fluid ounce. The method recommended

by Dr. Roberts is as follows: About four ounces of the saccharine urine are put in a 12-ounce bottle, and a lump of German yeast,* about the size of a small walnut, is added. The bottle is then covered with a nicked cork, to permit the escape of the carbonic acid, and set aside on a mantel-piece, or other warm place. Beside it is placed a tightly corked 4-ounce vial, filled with the same urine, but without any yeast. In eighteen to twenty-four hours fermentation will be complete, and the scum cleared off or subsided. The specific gravity of the decanted fermented urine is then taken; at the same time, that of the unfermented urine, and a comparison made. While some time is here required to complete the fermentation, yet, as Dr. Roberts says, the preparations can be made by the patient himself or friends, and each day, when the physician makes his visit, he has only to make the comparison.

2. *Volumetric Process.* *The exact quantitative methods* are those by Fehling's or Pavy's solutions. That recommended by Pavy is by far the most convenient in practice, requiring a hundred-minim graduated pipette,† a

* German yeast is not easily obtainable in this city, but the ordinary yeast answers as well.

† For some time it was impossible for me to get a minim pipette in this city. Finally I found they were to be had of W. H. Pile, northwest corner of Passyunk Avenue and Catharine Street, who prepares them with great care.

measuring glass, spirit-lamp and stand, and porcelain capsule.

In an ordinary case of diabetes, the urine contains too much sugar to be tried, unless diluted with a known quantity of water. Generally it suffices to dilute it with two to four times its bulk of water, according to the amount of sugar it is suspected to contain from the specific gravity.

One hundred minims of Pavy's solution, which, it will be recollected, are just decolorized by half a grain of sugar, are now measured out into a porcelain capsule. Into this a fragment of caustic potash, about twice the size of a pea, is dropped for the purpose of causing the reduced oxide to fall in a denser form, so that the liquid may remain clear, and allow the change of color to be more readily seen. The capsule is then placed over the flame of a spirit-lamp or gas, on a retort stand, or better, on a piece of iron gauze, adapted to the top of a stoneware cylinder, as arranged in the cut, Fig. 7. The cylinder protects the flame from draught, and the gauze distributes and regulates the heat.

The one hundred minim pipette is now filled with the mixture of urine and water, and as soon as the fluid in the capsule begins to boil, the contents of the pipette are allowed to fall drop by drop into the test solution in the capsule, which must be kept boiling, and moved about by tilting with a glass rod, until all the blue color is

gone. All trace of blue should be removed, and a little experience will enable even the beginner to note the exact point. If the deposit falls slowly, the process may be

Fig. 7. (From Pavy.)

stopped for a few minutes until it has subsided, when by tilting the capsule a thin layer of the fluid may be examined over the pure white porcelain, and thus any remaining coloration detected. We then note how many minims of the urine mixture have been used to decolorize the one hundred minims of test solution, thence the number of minims of pure urine, and thence the quantity in the whole twenty-four hours.

Thus, suppose the quantity of urine in twenty-four

hours to be 100 ounces, some of which was diluted four times—that is, of 100 minims of the mixture 20 were urine; suppose, further, that 80 minims of this mixture exactly reduced the 100 minims of solution representing the half grain of sugar. Then one-fifth only being urine, we have learned that 16 minims of urine contain half a grain of sugar, and from this that an ounce contains 15 grains and 100 ounces or the twenty-four hours' urine, $15 \times 100 = 1500$ grains.

Fehling's solution may be used in precisely the same manner, using however the metric system of measurement and operation, and obtaining results in the same system. Either solution may be dropped from a burette in a manner to be described in the volumetric analysis for urea, etc.

IX. Coloring Matters. The pathological significance of the coloring matters has recently assumed such importance that their consideration commands interest next to that of albumen and sugar.

I. *Normal Coloring Matters.* Notwithstanding the very considerable attention which has been given to this subject of late years, there is still some confusion as regards the normal coloring matters. Thus, perhaps most recently, Hoffmann and Ultzmann,* describing Scherer's method

* Anleitung zur Untersuchung des Harnes, etc. Wien, 1871.

of obtaining his urohæmatin, state that it does not contain iron, while the urohæmatin of Harley and the urophain of Heller do. Further, they make the *urohæmatin* of Harley identical with the *uroerythrin* of Heller, an abnormal coloring matter.

The fact is, that while it is probable that the true coloring matter of the urine has not been precisely determined, the urohæmatin of Scherer and Harley are identical, Scherer* admitting that urohæmatin contains iron, and approving of the use of the term by Harley for his coloring matter. The *urophain* of Heller is doubtless practically the same thing. It will at any rate here be so considered. Upon the presence of indican (Heller's uroxanthin) in normal urine, all are agreed. So that we may safely make two coloring matters in normal urine.

1. Urohæmatin (Harley and Scherer) or urophain (Heller).

2. Indican or the uroxanthin of Heller.

1. *Heller's test for urophain* is as follows: About 2 c. c. (32.4 minims) of colorless sulphuric acid are poured into a small beaker-glass, and upon it in a fine stream from a height of about four inches, two parts of urine are allowed to fall. The urine mingles itself intimately with the sulphuric acid, and in normal urine, of which the specific

* Harley: The Urine and its Derangements. Philadelphia, 1872, from London Edition, 1871.

gravity is 1020 and the quantity 1500 c. c. in the twenty-four hours, produces a *deep garnet red coloration.*

If the coloring matter is increased, the coloration is no longer garnet red, but is *black* and *opaque;* whereas, if the coloring matter is diminished, the mixture appears *pale garnet red* and transparent.

Precautions. Unfortunately, other conditions than that of increased amount of coloring matter produce the increased intensity of the urophain-reaction. Thus diabetic urine produces the same dark opacity through carbonization of the sugar by the sulphuric acid. In like manner, urine containing blood, biliary coloring matters, and uroerythrin (an abnormal coloring matter), gives the same reaction with sulphuric acid. Before relying, therefore, upon this reaction, the above substances must be carefully excluded.

Dr. Harley's test for urohæmatin is as follows: Dilute the twenty-four hours' urine with water till it measures 60 ounces (1800 c. c.), or if the quantity exceeds 60 ounces, concentrate it to this amount; then add to about 2 drachms (7.4 c. c.) of it in a test-tube, half a drachm (1.8 c. c.) of pure nitric acid, and allow the mixture to stand for some minutes. If the quantity of urohæmatin is normal, the mixture will alter but slightly in tint; whereas, if there be an excess, it will become pink, red, crimson or purple according to the amount present. Heating the mixture hastens the change in

color, but it is better to do this experiment in the cold, and, if necessary, allow plenty of time for the change to take place.

The acid is added to liberate the coloring matter, which may be so thoroughly concealed that a *pale urine often contains a large amount of urohæmatin.*

He gives a second method, also easy of application, of determining its excess in cases of destructive diseases of the blood. Boil 4 ounces (120 c. c.) of urine, and add nitric acid to set the coloring matter free. When cool, put the urine in a six-ounce bottle along with an ounce of ether. Cork the bottle, thoroughly shake it, and place aside for twenty-four hours. At the end of that time the ether will be found to be like a red, tremulous jelly. Such a case, however, he admits to be a bad one. He further says, that "in some of the worst cases of urohæmaturia the urine is neutral, or even alkaline and the *fons et origo mali* is to be looked for in the spinal cord."

Dr. Harley apparently with good reason considers that urohæmatin arises from the disintegration of the red blood-corpuscles, and that it fluctuates, therefore, with the rate of destruction of these.

2. *Indican* or *uroxanthin*, the second normal coloring matter of the urine is detected by Heller's test as follows: 3 or 4 c. c. (48.6 to 64.8 minims) of pure hydrochloric acid are poured into a small beaker-glass, and

into the same while stirring 10 to 20 drops of urine are dropped. Under normal conditions indican is present in urine in so small quantity that the acid to which the urine is added, is colored *pale yellowish-red.* If indican is present in larger quantities, the coloration is *violet* or *blue.* The more abundant the indican the more rapid does the violet or blue discoloration take place, and often 1–2 drops of urine are sufficient to color, 4 c. c. (64.8 minims) hydrochloric acid. If, however, the violet color does not appear in one or two minutes, the indican is not increased, even if after 10 or 15 minutes a dark reddish-brown color makes its appearance. If it is desired to test urine containing the biliary coloring matters for indican, the former must be precipitated by solution of acetate (sugar) of lead, and filtered out.

Indican itself is a colorless substance as is indigo at first, separable from urine in the shape of a clear brown syrup easily soluble in water, alcohol, and ether. It has a bitter taste, and is easily converted under warmth into *indigo-blue* (the uroglaucin of Heller), indigo-red (urohodin of Heller) and indigo-*glucin*, a saccharine substance which is said to respond to Trommer's test, but not to the fermentation test.

Dr. Harley believes that all the various colored urine pigments are but different grades of oxidation of urohæmatin,* and thus accounts for the various cases of blue,

* Op. citat., p. 110, ad fin.

green, brown and black urines which have been at different times reported, a most important fact with regard to which is that they never exhibit these colors at the moment the urine is passed, but acquire them after exposure to the air or the action of chemical reagents. He believes these changes which occur in urohæmatin out of the body, are primarily due to its constitution in the body having been altered by disease.

He admits, however, in common with others, that some portion of the coloring matter of the urine comes from the food, chiefly vegetable food.*

Clinical Significance of the Increased Urohæmatin or Urophain Reaction. An increase of the urophain (urohæmatin) reaction has been observed under the following circumstances (Hoffmann and Ultzmann):

1. In concentrated urines.
2. In fever urines.
3. In the urine of icterus and in chronic diseases of the liver. In the latter, and biliary obstructions, an increase of the urophain reaction may show itself, even when Gmelin's or Heller's test for the coloring matters of bile does not respond; since the products of their decomposition may be present when the proper biliary coloring matters themselves, bilirubin and bilifuscin, are wanting.

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* Op. citat., p. 101, ad fin.

4. In diabetic urine containing abundant sugar.

5. In urine rich in the coloring matters of blood.

6. A large amount of indican in the urine may also give a strong urophain reaction. So marked an increase in indican alone very seldom occurs, but it often happens that the blue color is recognized at the first moment of the test, and gradually passes over into the black; but by dilution with water the blue may again be made to appear.

Clinical Significance of Indican in the Urine. An increase of indican is found in renal diseases, especially the acute, in pyelitis, diseases of the spinal cord and its membranes, and especially derangements of the entire central and peripheral nervous system, in urina spastica, and after coitus.

It has been found by Neftel in cases of cancer of the liver, and its presence in large quantities, in persons affected with malignant tumors, he considers pathognomonic of cancer of the liver; by Hoppe-Seyler, in a case of melanotic cancer of the orbit. Jaffé finds indican increased in all diseases attended by intestinal obstruction, purulent peritonitis, certain forms of diarrhœa, and in various diseases where the latter is a symptom. Rosenstein found indican increased eleven to twelve times in Addison's disease. From these facts it is evident that it is difficult to associate it pathognomonically with any disease.

II. *Abnormal Coloring Matters.* Under abnormal coloring matters are included those which never enter into the composition of normal urine, whether found elsewhere in the body or not.

They include, *a, the coloring matters of blood*, hæmoglobin, methæmoglobin, and hæmatin. Hæmatin is a deoxygenated hæmoglobin, into which and a coagulated albuminous substance, hæmoglobin is converted by the action of heat. Methæmoglobin is an intermediate condition, approaching, however, nearer to hæmatin, and giving the same absorption band, in the yellow of the spectrum between Fraunhofer's lines C and D, but nearer to D, while hæmoglobin gives two bands in the yellow and green between D and E. *b*, the *uroerythrin* of Heller. *c, vegetable coloring matters. d, biliary coloring matters.*

a. The coloring matters of the blood, hæmoglobin, and *methæmoglobin*, and *hæmatin.* These substances can enter the urine either by direct transudation, or arise from the dissolution of blood-corpuscles themselves, which have entered the urine in different ways.

The color of the urine is different according as it contains more hæmoglobin or methæmoglobin, the former being brighter, the latter darker, brownish-red. Hemorrhages from the larger vessels produce more hæmoglobin; capillary hemorrhages, on the other hand, more methæmoglobin. Heller proposes to account for the difference in the fact that in the hemorrhages which take

place from the capillaries in the course of renal diseases, the blood is much more intimately and more slowly commingled with the urine, and therefore longer retained with the urine at the normal temperature of the body. Temperature, the presence of carbonic acid, and the absence of oxygen, may favor the passage of hæmoglobin to methæmoglobin.

Detection. 1. By Heller's hæmatin test, is as follows: Precipitate from urine in a test-tube the earthy phosphates by caustic potash and gentle heat over a flame. The earthy phosphates carry with them as they sink the blood-coloring matters, and appear therefore not white as in normal urine, but *blood-red.* When the quantity of coloring matter in urine is very small the earthy phosphates appear dichroic. If the urine is already alkaline, and no precipitate of earthy phosphate appears on the addition of liquor potassæ and heat, a precipitate can be artificially produced by the addition of one or two drops of the magnesian fluid, which, with the application of heat, carries down the coloring matters.

To Prepare Hæmin Crystals. If the precipitated earthy phosphates are filtered out and placed on an object-glass, and carefully warmed until the phosphates are completely dry, Teichmann's hæmin crystals can be produced therefrom. For this purpose a minute granule of common salt is carried on the point of a knife to the dried hæmatin and earthy phosphate, and gently mixed

with it. Any excess of salt is then removed, the mixture is covered with a thin glass cover, a hair interposed, and a drop or two of glacial acetic acid allowed to pass under. The slide is then carefully warmed until bubbles begin to make their appearance. After cooling, hæmin crystals can be seen by aid of the microscope, which, though often very small and incompletely crystallized, are easily recognizable by sufficient amplification.

Precautions. Care must, however, be taken to apply only a gentle heat in precipitating the earthy phosphate with caustic potash solution, and to filter quickly, else the hæmatin may be decomposed.

It sometimes happens also that vesicles develop under the thin glass cover, after the addition of acetic acid, even before heat has been applied. These are carbonic acid which has developed out of the earthy phosphates. These should be allowed to pass away, and then the slide warmed until the formation of vesicles, that is, to the boiling-point of acetic acid.

2. The blood coloring matters in urine may also be demonstrated by coagulating the albumen by boiling, filtering off the brown coagulum, drying and treating it with alcohol containing sulphuric acid. This alcoholic solution contains the hæmatin, and if the alcohol be evaporated, hæmin crystals can be obtained from the residue in the manner above described.

Occurrence. Hæmatinuria, that is the direct passage of the coloring matters alone from the blood into the urine, occurs in certain general diseases, as scurvy, purpura, scarlatina, etc. Hæmaturic or bloody urine occurs, of course, from a variety of causes which require no special mention. *These coloring matters of the blood, when present in urine, are always accompanied by albumen.*

b. Uroerythrin. Heller ascribes the well-known *dark reddish-yellow* or "high" color of all fever urines to the presence of a substance which he calls uroerythrin, as well as to an increase of the normal coloring matters. Except that it contains iron, little else that is certain is known with regard to uroerythrin. To it he ascribes the reddish color which so often characterizes the deposits of urates known as "lateritious;" if the supernatant urine in such cases be treated with solution of neutral acetate of lead, the precipitate presents a similar "rosy red" or "flesh color," which he attributes to the same substance. It is doubtless a modified hæmatin, being found especially in diseases where there is evident blood dyscrasia, as in low fevers, septic conditions, etc. It so far at least corresponds with the urohæmatin of Harley that it is a measure of the destruction of the blood-corpuscles, though it will be remembered that the urohæmatin of Harley is looked upon as a normal constituent of urine which may be abnormally increased, while uroerythrin, although a

modified hæmatin, is still not considered identical by its discoverer.

Detection. Uroerythrin is known to be present by its pink coloration of the "lateritious" sediment, or by its precipitation by solution of neutral acetate of lead. Too much lead solution must not be added lest the precipitate be too abundant, and therefore the coloring matter be rendered less distinct by its being disseminated over a large amount of deposit. If the urine contain hæmatin or the coloring matter of blood, it must first be removed.

Precautions. 1. The froth of a urine highly charged with uroerythrin may appear yellow, as that of urine containing biliary coloring matter, but the precipitate of the latter by acetate of lead is also yellow and not pink as with uroerythrin.

2. The earthy phosphates which are precipitated on heating the urine with caustic potash, are dirty gray when the urine contains uroerythrin, while in urine containing hæmatin they are "blood red" or dichroic. The absence of albumen from the urine, the gray coloration of the earthy phosphates, and the red precipitate with solutions of lead, serve as points in the differential diagnosis between uroerythrin and the coloring matter of the blood.

Clinical Significance. Uroerythrin is found in the urine in all febrile affections, even the slightest catarrh; especially in pyæmia, diseases of the liver, and lead colic.

All urine, according to Heller, which contains uroerythrin must be abnormal.

c. Vegetable Coloring Matters. The coloring matter of plants, especially chrysophanic acid found in rhubarb and senna leaves, contributes to alkaline urine a reddish-yellow to a deep red color. It can be recognized by the fact that the red alkaline urine by the addition of an acid becomes yellow, and by the addition of an excess of ammonia again takes on the red color.

Precautions. Such precipitation by heat and potash solution might possibly be taken for blood coloring matters. But the absence of albumen in the urine, the production of the red color by addition of an excess of ammonia, and its paling on the further addition of an excess of acid, serve to distinguish this vegetable coloring matter from blood coloring matter and uroerythrin.

Numerous other vegetable matters color the urine, among which santonin is conspicuous for the bright yellow color it produces in acid urine, while the staining of linen by it closely resembles that of biliary coloring matter.

Dr. W. G. Smith (Dub. Quar. Jr. Med. Sci., Nov. 1870) has investigated the subject, and found that the addition of an alkali causes the development of a *fine red cherry or crimson color*, according to the amount of santonin present; but it will be observed that this reaction is that

of the vegetable coloring matters generally, as above described.

Madder, gamboge, rhubarb, logwood, carrots, whortleberries, etc., give to urine more or less of their peculiar color.

d. Biliary Coloring Matters.—The Detection of Bile in the Urine. When bile is abundantly present in urine, the yellow color of the fluid, and especially of the froth or foam produced by shaking, is sufficient to excite suspicion. Further, if a piece of filtering-paper or a piece of linen be moistened with such urine, it retains a permanent yellow color on drying.

The only positive proof of the presence of the coloring matters of bile in the urine is found in Gmelin's or Heller's test for the unaltered coloring matters.

Gmelin's nitrous acid test is performed in two ways:

First. A quantity of urine is placed in a test-tube, and a small quantity of fuming nitric acid (nitrous acid of commerce) is allowed to pass carefully down the sides of the test-tube to underlie the urine as described in Heller's test for albumen. If biliary coloring matters are present, at the point of union between the urine and the acid will very soon be seen a set of colors which, if typical, should be *green*, *blue*, *violet-red*, and *yellow*, or yellowish-green again in the order named from above downward. Often, however, one or more colors are wanting. The green is most constant, and the *first* green *indispensable* to prove

the presence of bile, but violet shading into red and yellow is also very constantly seen.

A modification of this consists in mixing with urine in a test-tube weak nitric acid, and then passing under it as above pure sulphuric acid. The same set of colors occurs.

Second. Equally satisfactory is the test if a few drops of the urine are placed upon a porcelain plate, and as much of the fuming acid placed adjacent and allowed gradually to approach the urine. The same play of colors occurs.

Heller's test. Pour into a small beaker-glass about 6 c. c. (1.6 f℥) of pure hydrochloric acid, and add to it, drop by drop, just sufficient urine to clearly color it. The two are mixed and "underlaid" as before with pure nitric acid, and at the point of contact between the mixture and the colorless nitric acid, a handsome play of colors appears. If the "underlaid" nitric acid is now stirred with a glass rod, the set of colors which were superimposed upon one another now appear alongside of each other in the entire mixture, and should be studied by transmitted light. Heller further says, if the hydrochloric acid on addition of the biliary urine is colored *reddish-yellow*, the coloring matter is *bilirubin;* on the other hand, if it is colored *green* it is biliverdin.

If the amount of coloring matter is very small, a large quantity of urine should be shaken with chloroform; the

chloroform allowed to separate at the bottom of the vessel in large drops. The yellow-colored chloroform is then removed by means of a pipette, washed with distilled water, and poured into a beaker-glass containing hydrochloric acid. The yellow drops of chloroform sink to the bottom. If now while diligently shaking the glass, nitric acid is added, the changes of color can be distinctly observed in the chloroform. In consequence of the slower action of the acid upon the coloring matters dissolved in the urine and the consequent slower transition of colors, this method is peculiarly adapted for demonstration.

Precautions. 1. With neither test should too dark-hued a urine be employed, but it should first be diluted with water.

2. Should albumen be present, the opaque zone at the point of contact between the urine and acid imbibing the coloring matters will exhibit a green coloration, and so in no way interfere with the test.

3. Urine *rich in indican* may however deceive, forming at the point of contact a blue layer of indigo, which, along with the yellow urine in reflected light, may appear green. In these doubtful cases the chloroform modification of the test should be used, or the urine may be precipitated with solution of acetate of lead, and the filtrate examined for indican.

4. The earthy phosphates, precipitated from biliary

urine by liquor potassæ and heat, exhibit a brown coloration.

Test for Decomposed Biliary Coloring Matters. Should the urine contain only altered biliary coloring matters which respond neither to Gmelin's or Heller's test, it may be tried as follows:

A piece of white linen or filtering-paper is immersed in the suspected urine, and allowed to dry, when it will appear colored brown. A further confirmation that the decomposed coloring matters are present will be found in a low specific gravity and a dark urophain reaction. If, moreover, the urine be treated with liquor potassæ and heat, to precipitate the earthy phosphates, it becomes darker than before and the phosphates are precipitated brown.

X. The Biliary Acids. From a perusal of almost all of the existing text-books on physiology, and even of numerous manuals on the examination of urine, the student is led to suppose that the detection of bile acids, if present in urine, by means of what is called Pettenkofer's test, is one of the easiest possible. On the other hand nothing is farther from the truth, and the fact is that *such detection by the direct application of the elements of Pettenkofer's test in urine, or any other animal fluid, is practically impossible, even if the bile acids are present in considerable amount.* Nor have any of the modifications of Pettenkofer's test, recently announced as clinically

available, proved such in my hands, even where the elements of bile have been added to the urine, except where inspissated ox-bile has been used. The results of a complete investigation of this subject in its practical bearings will be found in a clinical lecture by the writer, in the *Philadelphia Medical Times*, for July 5th, 1873, "On a case of Jaundice, with remarks on the availability of Pettenkofer's test," to which the student is referred. In these experiments the simplest method of obtaining the biliary acids was found to be as follows: Six or eight ounces (180–240 c. c.) of the suspected urine are evaporated to dryness over a water-bath. The residue thus obtained is treated with an excess of absolute alcohol, filtered, and the filtrate treated with an excess of ether (12 to 24 times its bulk), by which the bile-acids, if present, are precipitated. These are then removed by filtration and redissolved in distilled water. The solution is then decolorized by passing through animal charcoal the resulting colorless fluid, tried by Pettenkofer's test as follows: A single drop of a 20 per cent. solution of cane-sugar (simple syrup of the Pharmacopœia is many times too strong) is then added to a drachm or two (3.7–7.4 c. c.) in a test-tube or porcelain capsule. Sulphuric acid is then added drop by drop, while the test-tube is kept in a vessel of cold water, to prevent too great a rise in temperature, which should not exceed 50°–70° C. (122°–158° F.). As the quantity added approaches a bulk

equal to that of the fluid tested, a beautiful *cherry red*, or *purple-violet* color should make its appearance. So soon as a yellow color makes its appearance, then the sulphuric acid is acting on the sugar, and the cherry red can no longer be looked for. This carbonizing of the sugar is obviated by keeping the temperature down to the degree mentioned.

Even this method involves more time than is often available to the active practitioner, but there is none more simple, and there is really rarely any necessity for any other than the color test, for the presence of the biliary acids, although undoubtedly occurring, is very rare, and the circumstances under which they occur are illy determined. It is not true, as was once supposed, that they are always present in the urine in cases of *obstruction*, and consequent *reabsorption* of bile, and absent in cases of *suppression*, else would the determination of their presence be of real value in diagnosis. The only circumstances under which they are undoubtedly present in the urine are as *rapidly* destructive diseases of the liver, as acute yellow atrophy, and phosphorus poisoning.

XI. Leucin and Tyrosin. Leucin and tyrosin, products of a retrograde metamorphosis of nitrogenous substances, are found physiologically only in certain fetid secretions, as those of the axilla and between the toes, but can be produced by chemical means from some

glands, as the liver, pancreas, and spleen, where they also occur in certain pathological states. They are found in the urine chiefly, in rapidly destructive diseases of the liver, as acute yellow atrophy, or phosphorus poisoning, but occasionally also in typhus and small-pox. They always accompany a large amount of biliary coloring matter, and the presence of albumen. When at all abundant, as they generally are in acute yellow atrophy, they are deposited from the urine and are found in the sediment, the former in the shape of centrically marked spheres, arranged in warty masses, or druses, the latter in needles. (Fig. 18.)

Schultzen has shown* that in animals poisoned by phosphorus, "urea disappears from the urine, and is replaced by leucin and tyrosin, which in the healthy organism are converted into urea." A similar substitution takes place, in cases of acute atrophy of the liver, the retained urea accounting for the convulsive attacks which usually precede death in these cases.

Detection. If the crystals, to be more fully described in treating of sediments, do not present themselves in the spontaneous deposit of such cases, the evaporation of a small quantity of the urine will generally promptly display them.

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* Boston Medical and Surgical Journal, July 23, 1874, from Zeitschrift für Biologie, viii, 124, and Berliner Wochenschrift, 1872, p. 417.

If they are not sufficiently abundant to be thus demonstrated, the method of Frerichs must be pursued to separate them. A large amount of urine is precipitated with basic acetate of lead, filtered, the excess of lead removed from the filtrate by sulphuretted hydrogen, and the clear fluid evaporated over a water-bath to a small volume. In twenty-four hours tyrosin needles will be found to have crystallized out, but leucin spheres will not appear until later, on account of their greater solubility.*

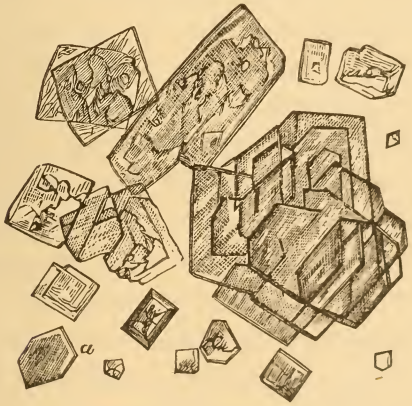
XII. Urea. CN_2H_4O. The chief organic constituent of the urine and the index of nitrogenous excretion, the quantity of urea fluctuates with changes in the quantity and composition of ingesta, and with the rapidity of tissue metamorphosis in health and disease. A range of from 20 to 40 grammes (308.6 to 617.2 grains) must at least be admited in adults.

Detection and Estimation. The odor of urine highly charged with urea, may be said to be characteristic, but certain evidence of its presence can only be obtained by treating the solution suspected to contain it with nitric or oxalic acid. Though crystallizing itself in glistening needles, it is too soluble to permit of easy detection by

* Leucin and tyrosin are more fully treated by the writer in the American Journal of the Medical Sciences for January, 1872. The above is believed to be sufficient for practical purposes.

its own form. If it be desired to detect its presence in a suspected fluid, a drop or two is placed upon a glass slide, a drop of nitric acid added, the slide carefully warmed over a spirit-lamp, and placed aside to crystallize. If urea is present, the microscope will reveal singly or in plates six-sided, and quadrilateral crystals of nitrate of urea, Fig. 8. The crystals have acute

FIG. 8. (After Beale.)



Crystals of nitrate of urea.

angles measuring about 82°, and are so characteristic as to be easily recognizable.

In the plates the crystals often overlap each other like the shingles of a roof. Solution of oxalic acid produces similar but less regular crystals of oxalate of urea.

In ordinary healthy urine, this crystallization does not take place unless the urine is concentrated by evaporation. But in some urines highly charged with urea, it is simply necessary to add nitric acid to produce the crystals, and thus is arrived at a rough quantitative estimation for urea.

As urea is by far the most abundant solid constituent of the urine, it follows that the specific gravity may become a means of approximately estimating its amount, especially when there is no sugar present, if the quantity of albumen is small, and that of the chlorides is normal. A specimen of urine, containing neither albumen or sugar, a normal proportion of chlorides, and a specific gravity of 1020–4 to a quantity of 1500 c. c. (50 oz.) in twenty-four hours, may be taken as a standard normal specimen containing 2 per cent. to $2\frac{1}{2}$ per cent. of urea. These conditions being observed, a higher specific gravity would indicate an increased proportion of urea, and a lower a diminished proportion. Under these circumstances, a specific gravity of 1014 indicates about 1 per cent. of urea, and of 1028 to 1030 about 3 per cent.

But the chlorides fluctuate markedly in some diseases, and by far the largest proportion of urines, in which a knowledge of the amount of urea is important, contain albumen. Next to urea, supposing albumen and sugar absent, the chlorides most affect the specific gravity,

being separated to the amount of 10 to 16 grammes (154 to 247 grains), or $\frac{2}{3}$ to 1 per cent. in the twenty-four hours. If these are totally absent, as they often are in pneumonia and other febrile diseases, characterized by an increase in the elimination of urea, then must a specific gravity of 1020 indicate more than $2\frac{1}{2}$ per cent. of urea, or if the percentage of chloride replaced by urea be added, $3\frac{1}{2}$ per cent. This is supposing, of course, as is the case, that the remaining constituents, uric acid, creatinin, phosphates, sulphates, etc., have little influence on the specific gravity.

If albumen is present in small quantity, not exceeding $\frac{2}{10}$ per cent., as determined by the approximative method given for albumen, it has little effect, and it can be thrown out of the question. If, however, the albumen be more abundant, 1 to 2 per cent., it must first be removed by coagulation and filtration, and the approximate estimation be made from the specific gravity of the filtrate after cooling. Care must of course be taken to wash the coagulum by further addition of water until the quantity of fluid originally operated with is restored. After such removal of albumen, if not before it, the specific gravity will generally be found diminished, showing what volumetric analysis has determined more precisely, that in chronic albuminuria, at least, the quantity of urea is generally diminished.

Where sugar is present the percentage of urea is also

generally less, though with increased specific gravity, while the large total quantity of urine in the twenty-four hours may show an increase in the total urea for the day. There is no way of allowing here for the increased specific gravity due to the presence of sugar, and the only way to arrive at a knowledge of the amount of urea is by volumetric analysis.

Volumetric Analysis. Under any circumstances, when an accurate estimation of urea is required, we must have recourse to volumetric analysis. Several methods of volumetric analysis for urea have been suggested, of which that of Liebig, with the nitrate of mercury solution, seems most to combine accuracy and convenience. Davy's method, with the sodium hypochlorite and pure mercury, is, in some respects, more simple, but it is also more liable to error, and really takes more time for its completion, while Liebig's process is carried out with surprising celerity, after even a little experience, not more than fifteen minutes being required to complete it if the solutions are at hand.

Liebig's process is based upon the fact that urea produces an insoluble precipitate with mercuric nitrate.

The following test-solutions are required :

1. *The Baryta solution*, consisting of one volume of cold saturated solution of barium nitrate, with two volumes of cold saturated solution of caustic baryta (barium hydrate).

2. A saturated solution of sodium carbonate, or some filtering-paper impregnated with the latter.

3. *A standard solution of mercuric nitrate* of such strength that 1 c. c. is precisely equivalent to .010 gramme, or 10 milligrammes of urea (.15 grain).

To Prepare the standard Solution of Mercuric Nitrate. 1. Dissolve about 75 grammes (1157.25 grs.) of pure mercury in pure boiling nitric acid. The acid fluid is concentrated by evaporating over a water-bath to a syrupy consistence, and then diluted to the volume of a litre (2.1 pints) of distilled water. Unless a great excess of acid remains after evaporation, a white precipitate of basic nitrate of mercury will fall, which must be removed by filtration; previously, however, a few drops of nitric acid should be added which will dissolve the greater part of the precipitate without making the solution too acid. The solution requires to be graduated by

2. *The standard Solution of Urea.* Two grammes (30.86 grs.) of pure urea should now be dissolved in 100 c. c. (27 f℥) of distilled water, of which 10 c. c. (2.7 f℥) will then contain 0.2 gramme (3.08 grs.) or 200 milligrammes.

Ten c. c. of this standard solution containing 200 milligrammes of urea are now placed in a beaker-glass. A burette is then filled to 0 with the solution of mercuric nitrate (taking care that the lower edge of the meniscus which forms the upper surface of the liquid corresponds with the arrow on the burette), which is then allowed to drop into the beaker, where it will quickly form a dense precipitate. When the precipitation seems nearly com-

plete, a drop of the fluid containing it is allowed to fall on a drop of the solution of sodium carbonate on a piece of glass on a dark ground, or on a piece of filtering-paper impregnated with the sodic solution. If the urea is not completely precipitated, no change of color takes place. The cautious addition of the mercuric nitrate is continued, and the process of testing with the Na_2CO_3, until finally a yellow color appears. This proves that the mercuric nitrate has been added in excess,—consumed all the urea in combination and left some mercuric nitrate to react with the sodic carbonate, which it does by forming sodic nitrate and the yellow oxide of mercury.

The number of cubic centimetres consumed in reaching the point as read off on the burette, indicates the quantity of mercuric nitrate which is equivalent to 200 milligrammes of urea. Whence it is easy to calculate how much further the solution should be diluted to make 10 c. c. = 100 milligrammes of urea or 1 c. c. = .010 gramme (10 milligrammes).

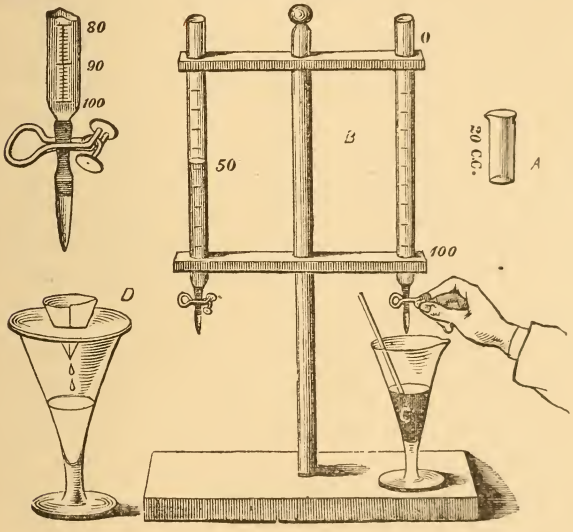
Thus suppose that 17.3 c. c. (4.67 f℥) of the solution of mercuric nitrate are required to precipitate the .200 gramme of urea; then, if 2.7 c. c. (.73 f℥) water are added to this quantity, we will have 20 c. c. = .200 gramme or 10 c. c. = .100 gramme or 1 c. c. = .010 gramme or 10 milligrammes as required.

It is scarcely necessary to say that the quantity (75 gms.) of mercury originally taken is selected, because it is known that that amount treated as above and diluted to a litre will give very nearly the proportion required.

Process. Take 40 c. c. (10.8 f℥) urine and 20 c. c. (5.4

f3) of the baryta solution, and throw them into a beaker-glass. By this means the phosphates, sulphates, and carbonates are precipitated. They are removed by filtration through a *dry* filter, and if the filtrate happen not

FIG. 9. (After Harley.)



to be quite clear, it may be passed through a second time. While this is taking place, the burette is filled to 0 with the mercuric nitrate solution, and 15 c. c. (2.7 f3) of the filtrate from the mixed baryta fluid and urine, containing of course 10 c. c. (2.7 f3) of pure urine, are measured off into a small beaker-glass. Into this the mercuric nitrate solution is allowed to fall from the burette, first,

to a number of cubic centimetres approaching the last two figures of the specific gravity (that is, if the specific gravity is 1017, drop 15 c. c.) before testing with the soda solution or soda paper. If no yellow coloration appears, then proceed cautiously, a cubic centimetre or two at a time, testing with the Na_2CO_3 until the yellow coloration is struck. When that point is reached, read off the number of cubic centimetres employed. The number of cubic centimetres of mercury solution thus used, minus 2 and multiplied by .010 gramme, gives the amount of urea in fractions of a gramme contained in 10 c. c. (2.7 f℥) of the urine, when the latter is of average composition, that is when it contains nothing abnormal, and the amount of chlorides is about the average.

The two cubic centimetres are first subtracted because it takes about this quantity to decompose the chlorides which first form a soluble precipitate with the mercuric nitrate, and until they are all thrown down, the combination with the urea does not begin. Hence this amount must first be subtracted.

If, however, the chlorides are not of average amount but diminished or increased, and we wish to be accurate, we must first estimate the amount of chlorides calculated as NaCl in 10 c. c. of the urine, by the process to be explained under chlorides, and the whole of the chlorides must be removed from a fresh quantity of urine by a standard solution of silver nitrate. For this purpose a solution

of nitrate of silver is required of strength corresponding to that of the mercuric nitrate solution, *i. e* , such that 1 c. c. will precipitate 10 milligrammes sodium chloride. 11.601 grammes (179.00 grs.) of fused nitrate of silver, dissolved in distilled water, and diluted to a litre, will be such a fluid.

Take 30 c. c. (8.1 f℥) of the filtrate from the mixture of baryta fluid and urine, add a drop of nitric acid, and drop in from the burette twice as many cubic centimetres of the nitrate of silver solution (supposing 15 c. c. to have been the quantity there operated with) as cubic centimetres of the nitrate of mercury solution used *in the chlorine estimation.* A precipitate of the chlorides will take place, which should be removed by filtration, and the filtrate may be now estimated for urea. It is only necessary always to bear in mind the exact amount of urine operated with after adding the nitrate of silver solution to a mixture of baryta solution and urine, of which only two-thirds are urine. Thus if 10 c. c. of the silver solution are added to 30 c. c. of the filtered mixture of urine and baryta fluid, of the resulting 40 c. c., 20 would be urine minus the chlorine, or out of 20 c. c. 10 would be urine minus the chlorine.

If the case be one of inflammation, as pneumonia, where there is a total or almost total absence of chlorides, they may be thrown out of the question altogether.

Further correction. If the number of cubic centimetres of mercury solution added to 15 c. c. of the mixture of urine and baryta fluid exceeds 30, the process must be repeated, adding to 15 c. c of the liquid as many cubic centimetres of distilled water as equals the difference between 30 and the number used in the first operation.

XIII. URIC ACID—$C_{10}H_4N_4O_6$. When uric acid is spoken of as a constituent of urine, it is never to its free state that allusion is made, but to its combinations chiefly with potash, soda and ammonia, but also with lime and magnesia, usually known as mixed urates. Uric acid itself is so extremely insoluble (one part requiring 14,000 of cold and 1800 of hot water to dissolve it) that it is immediately precipitated on being freed of its bases. In quantity it is found ranging .4 to .8 gramme (6.17 to 12.34 grs.) in the twenty-four hours, in health varying *pari passu* with urea of which it is a stage short in oxidation.

Detection by the Microscope. Its presence as such is recognized by the microscopic characters of its crystals, which in their typical form may be said to be "lozenge-shaped," or as best described by the Germans "whet stone-shaped." They are, moreover, always colored yellowish-red or red, being with their salts the only urinary deposits thus stained, so that when a sediment is seen of which the elements are thus colored, it may, without hesitation, be put down as composed of uric acid or its combinations. More will be said of these crystals in treating of sediments, where their discussion more properly belongs.

The Murexid test. The murexid test for uric acid and its combinations is one of extreme beauty. A small portion of sediment, or the residue after evaporation, is

placed on a porcelain plate or piece of platinum, a drop or two of nitric acid added to dissolve it, and then carefully evaporated over a spirit-lamp flame. When dry, a drop or two of liquor ammonia is added, when there promptly appears a beautiful purple color, which will gradually suffuse itself as the ammonia spreads. The murexid reaction is believed to depend upon the origin of alloxan, alloxantin, and ammonia, under the action of the hot nitric acid. This reaction is also said to occur with tyrosin, hypoxanthin, and xanthoglobulin, and Schiff accordingly recommends the

Carbonate of Silver Test for Urea. This is very delicate, and is most conveniently applied as recommended by Harley. Dissolve a little uric acid in a solution of sodium or potassium carbonate, place a drop or two of the solution on paper, and add a solution of nitrate of silver. A distinct gray stain promptly occurring indicates the presence of uric acid.

Neither of the tests, however, discriminates between uric acid and urates. The microscope alone can do this.

Quantitative Estimation of Uric Acid. To 200 c. c. (54 f℥) add 20 c. c. (5.4 f℥) of hydrochloric or nitric acid, and set aside in a cool place, as a cellar, for twenty-four hours. At the end of that time the uric acid crystals, highly colored, will be found adhering to the sides and at the bottom of the beaker. Collect the uric acid on a weighed filter, wash thoroughly with distilled water. Dry the filter and uric acid at a temperature of

100° C. (212° F.), weigh, and the weight of the two, minus the weight of the filter, will be the weight of the uric acid in 200 c. c., except the small portion retained in the acid and washings. Neubauer advises to add to the result 0.0038 grammes uric acid for every 100 c. c. of these fluids.

XIV. URATES. It has already been said that in health, practically all the uric acid of the urine is held in combination with potash, ammonia, soda, lime, and magnesia, of which those with potash and ammonia are most abundant according to Bence Jones. These are very soluble compounds at the temperature of the body, but are precipitated in amorphous granules when the temperature of the urine is lowered, as in winter weather.

Their physiological and pathological significance depends altogether upon the uric acid they contain, but there are some points of reaction with which the student should be quite familiar. These grow out of the fact that uric acid is a bibasic acid, forming neutral and acid salts, and that *the acid salts are much less soluble than the neutral,* requiring 124 parts of boiling and 1120 parts of cold water for their solution. They form, therefore, the bulk of urate deposits, while urates, which remain in solution after such reduction of temperature as constantly takes place in an apartment, must be, if not neutral, at least less acid than those which form the sediment. And a solution remaining for some time

clear under such circumstances, must contain urates of soda, etc., with a large proportion of the alkaline base.

The practical application of this fact is seen in this, that when an acid is added to such solution of neutral urate, by seizing upon a portion of the base, it leaves an *acid* urate of soda, which, in consequence of its relative insolubility, is promptly precipitated in a finely *granular* form, producing a decided opacity. Now, this is precisely what often happens in the nitric acid test for albumen. The urine is highly charged with neutral urates which are held in solution. Nitric acid is added, and down goes a precipitate, not crystalline, but *amorphous*, which is composed of acid urate of soda. And if Heller's method is followed, an opaque zone is formed at the point of contact between the acid and urine, which may be mistaken for albumen, but which, besides presenting certain visual characters of its own, which have been described, p. 38, is readily soluble by heat. If urine presenting this reaction with acid be allowed to stand for some time, the milky opacity gradually passes away, and is substituted by a very small crystalline sediment of uric acid. By longer action of the acid, the remainder of the base is entirely withdrawn, leaving the free acid, which is deposited in crystals.

The remaining organic constituents of the urine, creatinin, creatin, xanthin, hippuric acid, oxalic acid,

lactic acid, and phenylic acid, having little practical significance as such, require only to be mentioned in this connection.

Mucus and the crystalline combination of *oxalic acid* with lime will be further considered in treating of sediments.

Hippuric acid is interesting in forming one of the most striking connecting links between the urine of carnivora, omnivora, and herbivora, replacing in the last the uric acid of the first, while in man, who consumes a mixed diet, we have both uric acid and hippuric, that is, an intermediate state. But while hippuric acid is increased in man by a vegetable diet, yet it is not wholly absent with animal food. It is increased in diabetes, where also it almost replaces uric acid. If 10 grains benzoic acid be taken in the evening, the next morning crystals of hippuric acid will usually be found in the urine. The typical form of these is a four-sided prism, with two or four bevelled surfaces at its ends, but from this there are deviations. In the twenty-four hours' urine of man, .5 to 1 gramme (7.7 to 15.4 grs.) are separated.

Inorganic Constituents.

XV. The Chlorides. The chlorides found in the urine are chiefly those of sodium, with a small proportion of chloride of potassium and ammonium.

In health the chlorides are almost an exact measure of the same substances taken in with the food, and amount to 10–16 grammes (154.3 to 246.8 grs.)

Detection and approximate Estimation. If a drop of urine be slowly evaporated on a glass slide, characteristic octahedral crystals and rhombic plates of a combination of urea and chlorine make their appearance, and may be examined by the microscope. But more available for detection and approximate estimation is

The Nitrate of Silver Test. Nitrate of silver in solution throws down both the phosphates and chlorides from the urine. But if a few drops of nitric acid be first added, the phosphates will be held in solution, and only the chlorides will fall as opaque white chloride of silver.

From normal urine containing $\frac{1}{2}$ to 1 per cent. of chlorides, they are precipitated by a *single* drop of a solution of nitrate of silver, 1 part to 8, in cheesy lumps, which do not further divide themselves, or make the urine more milky by moving the glass about. *If, however, the chlorides* are *diminished* to $\frac{1}{10}$ per cent. or less, the addition of a single drop of the silver solution no longer produces the white cheesy lumps, but a simple cloudiness, and the entire fluid appears equally milky. If, finally, there should be no precipitate whatever, then the chlorides are totally absent.

The presence of albumen in moderate amount does

not interfere with the test, but if abundant, it must be removed.

Clinical Significance. The chlorides are diminished in all febrile conditions, whether of local or general origin. Especially is this the case where there are any exudations, solid or fluid, by which they seem to be eliminated. In acute pneumonia, where they are often totally absent from the urine, they appear abundantly in the saliva. In this affection, and indeed, in all acute diseases, their disappearance from the urine indicates an increment in the disease, and their reappearance an improvement. In pneumonia a decline in the disease may often be detected through their return before physical or any other signs point to improvement. Hence a daily trial of the urine for them becomes important.

Volumetric Process. The volumetric process employed may be that of Liebig with solution of mercuric nitrate, or that with silver nitrate.

Liebig's process depends upon the fact that chlorine forms with urea a soluble compound, and urea an insoluble precipitate; and the precipitate with urea does not appear until all of the chlorides are consumed in combination. The solution of nitrate of mercury is less concentrated than that employed for the urea, in order that the chlorides may not be thrown down too rapidly for accurate observation.

The solutions required are:

1. A solution of sodium chloride, 20 grammes (308.6 grs.) of the pure salt, which should be fused before being weighed, in a litre of distilled water. Of this 10 c. c. (2.7 f ʒ) = 0.200 grammes (3.08 grs.) NaCl.

2. A solution containing 4 grammes (61.72 grs.) pure urea in distilled water, and diluted to 100 c. c. (27 f ʒ).

3. A solution of sodium sulphate saturated at ordinary temperature.

4. A baryta solution as for urea (1 barium nitrate, 2 caustic baryta).

5. A solution of mercuric nitrate of such strength that 1 c. c. = 10 milligrammes (0.010 grammes) of sodium chloride, or 16.2 minims = .154 grains.

To Prepare Solution of Mercuric Nitrate. Dissolve 20 grammes (308.6 grs.) of pure metallic mercury in boiling nitric acid, until a drop of the acid fluid does not precipitate when added to a solution of common salt. Concentrate this fluid to a syrupy consistence over a water-bath, and dilute to nearly a litre of distilled water.

To determine the strength of this solution, place 10 c. c. (2.7 f ʒ) in a beaker, and add 3 c. c. (48.6 minims) of the solution of urea, and 5 c. c. (1.35 f ʒ) of the solution of sodium sulphate. Into this allow the solution of mercuric nitrate slowly to drop from a burette. As each drop touches the fluid, a white precipitate is seen to fall, which is promptly redissolved on stirring the mixture. Finally,

however, a point is reached, when the opalescence remains permanent. This shows that all of the chloride of sodium is decomposed, and the insoluble precipitate of mercuric nitrate with urea has commenced to form.

The number of cubic centimetres required to decompose .200 grammes (3.08 grs.) NaCl is then read off, and from these data, calculated as described under urea, the quantity of water to be added to make 10 c. c. correspond to .100 grammes sodium chloride, or 1 c. c. to .010 grammes, or 10 milligrammes.

Process. The phosphates and sulphates are precipitated from 40 c. c. urine by 20 c. c. baryta solution, as with urea. Of the filtrate, 15 c. c. containing 10 c. c. of urine are placed in a beaker-glass, and acidulated with 2 or 3 drops of nitric acid, just sufficient to cause it to turn blue litmus-paper red.

The burette is then filled to 0 with the mercuric nitrate solution, and this allowed to drop into the beaker containing the urine, until a permanent precipitate begins to form.

The number of cubic centimetres used, multiplied by .010, gives the quantity of chlorine calculated as NaCl, in fractions of a gramme, whence the twenty-four hours' quantity is easily estimated.

Mohr's nitrate of silver method is preferred by Neubauer,* because Liebig's method, if not very exactly

* Neubauer and Vogel, Analyse des Harns, VI Aufl., 1872, p. 169.

carried out, gives incorrect results. There are required:

1. A cold saturated solution of neutral chromate of potash.

2. A solution of nitrate of silver, such that 1 c.c = 10 milligrammes NaCl. This is made by dissolving 29.075 grammes (448.62 grs.) pure fused nitrate of silver in distilled water, and diluting to a litre.

Process. Put 10 c.c. (2.7 f℥) of the urine in a platinum crucible, dissolve in it 1 or 2 grammes (15.43 or 30.86 grs.) potassium nitrate free from chlorides, and evaporate the whole slowly to dryness. Expose the remainder, first to a gentle and afterwards to a strong heat until the carbon is completely oxidized, and the residue a white molten saline mass. The entire white mass is then dissolved in a little water, placed in a beaker-glass, the platinum capsule washed off into it with the wash-bottle. Dilute nitric acid is then carefully dropped into the alkaline fluid until it is faintly acid, and a small pinch of calcium carbonate is then introduced to make it neutral, the excess of lime filtered off. To the mixture, 2 or 3 drops of the potassium chromate solution are now added, and the silver solution allowed to flow in from the burette while stirring the mixture, until a distinct red color remains. The color continues canary yellow until all the chlorides are decomposed. As each drop falls into the urine, it must be carefully watched for the least

tinge of red surrounding the precipitate of chloride of silver; the very next drop after the complete decomposition of the chlorides, gives a permanent red color, due to the presence of silver chromate. The number of cubic centimetres consumed × .010, will give the amount of chlorides, estimated as NaCl in 10 c. c. urine, whence the total is calculated.

XVI. PHOSPHATES. The phosphates of the urine are composed partly of *earthy* and partly of *alkaline* phosphates. The former are insoluble in water, but soluble in acids; they are held in solution in acid urine by free carbonic acid, and precipitable from it by alkalies. The *alkaline* phosphates are soluble in water and not precipitated from solution by alkalies.

a. The *earthy phosphates* are phosphates of lime and magnesia, and are contained in urine in but small quantities—1 to 1.5 gramme (15.43 to 23.14 grains) in twenty-four hours.

Detection and Approximate Estimation. The presence of the earthy phosphates is shown by adding any alkali as caustic ammonia or potash.

Their quantity may be *approximately* estimated in the following simple way, given by Hoffmann and Ultzmann. A test-tube, 16 centimetres (6.2992 inches) long, and 2 centimetres (.787 inch) wide, is filled one-third with clear or filtered urine, to which a few drops of caustic ammonia or caustic potash solution are added and warmed gently over

a spirit-lamp until the earthy phosphates begin to separate in flakes. It is then placed aside for ten or fifteen minutes for them to subside. If the layer of sediment is 1 centimetre (.3937 inch) high, the earthy phosphates are present in normal amount; if they occupy 2 to 3 centimetres (.787 to 1.181 inch), they are increased; if, on the other hand, only a few flakes are visible, the earthy phosphates are diminished.

Further, in normal urine the earthy phosphates are precipitated white, but if the urine contains abnormal coloring matter, they fall variously colored. If the urine contains blood coloring matter, the earthy phosphates appear blood red or dicroic; if there be present vegetable coloring matters, as of rhubarb, senna, etc., they are colored rosy red to blood red, and by the biliary coloring matters yellowish-brown, and by uroerythrin gray.

The earthy phosphates are deposited from alkaline urine, and a most important precaution here must be observed not to mistake such a *deposit* for an excess of phosphates. The phosphates may really be *diminished*, and yet in consequence of the reaction of the urine a copious *deposit* may be present. The possible *precipitation of earthy phosphates by heat alone* as a source of error in testing for albumen, has already been alluded to. This frequently occurs, and is best explained on the supposition of Dr. Brett, that the earthy phosphates are held in solution in urine by carbonic acid, which being dissipated

by heat allows the phosphates to fall. It should be further stated, however, that Dr. Owen Rees believes the phosphates are held in solution by chloride of ammonium, which would also be dissipated by heat. Dr. Bence Jones attributed this precipitation to a neutralization of the excess of free acid in the urine by an alkali or free phosphate of soda.

Clinical Significance. The earthy phosphates are increased in the urine by diseases of the bones, especially if extensive, as in osteomalacea and rickets, in chronic rheumatoid arthritis, in diseases of the nerve-centres, and after great mental strain; but especially are the earthy phosphates increased by the food and drink, some contending that all variations in the earthy phosphates are due to this cause. In renal diseases, on the other hand, the phosphates are diminished. Earthy phosphates are often found deposited in conditions of dyspepsia and overwork, but this may generally be traced to changes in the reaction of the urine.

b. The alkaline phosphates, soluble in water and not precipitated by ammonia or alkalies, form the chief bulk of the phosphates, averaging, according to Breed, 4 grammes (61.72 grains) in the twenty-four hours, though Neubauer by volumetric analysis has seldom found more than 2 grammes (30.86 grains) in this period. Four grammes correspond to two grammes phosphoric acid. They are almost wholly made up of *acid sodium phos-*

phate with possible traces of potassium phosphate. The acid sodium phosphate was believed by Liebig to be the cause of the acid reaction of the urine.

Approximate Estimation of Alkaline Phosphates. Accurately to estimate the alkaline phosphates, it would be necessary, first, to remove the earthy phosphates, which may easily be done by precipitating them with ammonia and filtering out. For approximate estimation, however, this is not necessary, since they are in the first place present in comparatively small quantity, and, secondly, do not vary much in disease. Practically, therefore, they are disregarded, and to a suitable quantity of urine placed in a beaker-glass about one-third as much of the magnesia fluid (p. 16) is added. *All* of the phosphates are thrown down in the shape of a snow-white deposit composed chiefly of ammonio-magnesian phosphate and amorphous phosphate of lime. If the entire fluid present a *milk-like cloudy appearance*, the alkaline phosphates may be considered present in normal amount; if it is denser, more cream-like, there is an increase. If, on the other hand, the fluid is but slightly cloudy, transmitting light distinctly, the phosphates are diminished.

Nitrate of Silver test. A solution of nitrate of silver added to urine throws down a yellow precipitate of phosphate of silver, and chloride of silver. Both are soluble in *ammonia*, the silver phosphate also in nitric acid, but not the chloride. If, therefore, a few drops of ammonia

be added, they will promptly disappear. If now nitric acid, just sufficient to neutralize the ammonia, be added, the precipitate will again reappear; but the moment the nitric acid is present in excess, the silver phosphate is redissolved, but the chloride remains in suspension. If now enough ammonia be added again to neutralize the nitric acid, the phosphate of silver will again fall; but if an excess be added, the entire precipitate, including the chlorides, will be redissolved.

Clinical Significance. The alkaline phosphates in the urine are influenced chiefly by the food, whence they are mainly derived; phosphorus is also oxidized in the economy, and a small part of the phosphates is doubtless derived from the disintegration of nervous and muscular tissues. Any increased activity of vital processes, as inflammations and fevers, would, therefore, favor their increase.

Volumetric Process for Phosphoric Acid. This process is based upon the facts that,

1. When a solution of phosphate acidulated with acetic acid is treated with a solution of nitrate or acetate of uranium, a precipitate falls which is composed of uranium phosphate.

2. When a soluble salt of uranium is added to a solution of potassium ferrocyanide, a reddish-brown precipitate or color is developed.

The solutions required are,

1. A standard solution of sodium phosphate, made by dissolving 10.085 grammes (155.60 grs.) of well-crystallized sodium phosphate ($Na_2HPO_4 + 12H_2O$) in distilled water, and diluted to a litre (33.8 f℥); 50 c. c. (13.5 f℥) then contain .1 gramme (1.54 grs.) P_2O_5.

2. Saturated solution of potassium ferrocyanide or filtering-paper saturated with the same and dried.

3. Sodium acetate solution, made by dissolving 100 grammes (1543 grains) sodium acetate in 100 c. c. (27 f℥) pure acetic acid, and diluting with distilled water to 1000 c. c. (33.8 f℥).

4. Solution of uranium acetate, such that 1 c. c. will correspond to .005 grammes or 5 milligrammes phosphoric acid.

To prepare the Uranium Acetate Solution. Dissolve 20.3 grammes (313.2 grs.) of pure uranic oxide in strong acetic acid, dilute with distilled water to nearly a litre. To determine the strength of this solution, place 50 c. c. (13.5 oz.) of the standard solution of sodium phosphate in a beaker with 5 c. c. (1.35 f℥) of the solution of sodium acetate and heat in a water-bath to 90° to 100° C. (194° to 212° F.). The uranium solution is then allowed to run from a burette into the warm mixture until precipitation ceases. Then a drop of the mixture is carried by a glass rod into contact with a drop of the ferrocyanide of potassium solution on a white plate, or to a piece of the filtering-paper impregnated with it. If the reddish-brown of the uranium ferrocyanide does not appear, continue the cautious addition of the uranium

solution until the color responds to the test. The quantity used is then read off, being that which is sufficient to decompose sodium phosphate corresponding to .1 gramme (1.54 grs.) of P_2O_5, whence is calculated the amount of distilled water to be added to make 1 c. c. correspond to .005 gramme (.077 grain) of phosphoric acid.

Process. Take 50 c. c. (13.5 f℥) of urine; add 5 c. c. (1.35 f℥) of the sodium acetate solution and warm in a water-bath as above. Fill the burette with the uranium solution, and drop it into the mixture while warm, testing with the ferrocyanide solution or papers as above. The number of cubic centimetres used multiplied by .005 will give the phosphoric acid in the 50 c. c. of urine, whence calculate the quantity for the twenty-four hours.

XVII. SULPHATES. The sulphates found in the urine are those of soda and potash, the former preponderating. The quantity in twenty-four hours is 3 to 4 grammes (46.29 to 61.72 grains) corresponding to 2 grammes (30.86 grains) sulphuric acid.

Detection and Approximate Estimation. This is simple with any of the barium compounds which throw down a white precipitate of barium sulphate. A little acid, as hydrochloric, should previously be added, in order to hold in solution the barium *phosphate*, which is otherwise thrown down, or the acid may be previously added to a solution of barium chloride.

If to a small quantity of urine in a beaker-glass, one-

third as much of the acidulated solution of barium chloride (1 part to 8 plus $\frac{1}{2}$ a part hydrochloric acid) is added, and there occurs an *opaque* milky cloudiness, the proportion of sulphates is normal; if the opacity is intense, and the whole mixture has the appearance and consistence of cream, the sulphates are increased; if, on the other hand, there is only a slight cloudiness, so that light is still transmitted, the sulphates are diminished.

Clinical Significance. The sulphates are derived partly from the food and partly from the tissues, are increased by the introduction of sulphur compounds, sulphuric acid and its soluble combinations, by an animal food, and by any causes producing increased rapidity of tissue change, as active exercise, the introduction of oxygen, febrile movements, and fevers. The greatest increase has been observed in meningitis, cerebritis, rheumatism, and affections of the muscular system. They are diminished in an exclusively vegetable diet.

The volumetric process for sulphuric acid depends upon the principle that a solution of chloride of barium will throw down a precipitate from a given quantity of urine, so long as any sulphuric acid is present; and further, that in thus treating a specimen of urine acidulated with HCl, a neutral point is reached at which the filtrate will show a slight opacity as well with the sulphuric acid, as with the barium chloride solution. In such a fluid we are to suppose potassium chloride, barium chloride,

and potassium sulphate, balancing each other. If now either barium chloride or potassium sulphate are added, it itself is decomposed, and barium sulphate precipitated.

The solutions required are,

1. Solution of barium chloride so concentrated that 1 c. c. will precipitate exactly 10 milligrammes H_2SO_4; prepared by dissolving 30.5 grammes (470.6 grs.) dry crystallized chloride of barium, and diluting to a litre (33.8 f℥).

2. Solution of potassium sulphate such that 1 c. c. = 10 milligrammes H_2SO_4; prepared by dissolving 21.778 grammes (336.03 grs.) chemically pure powdered potassium sulphate, dried at 100° C. (212° F.), and diluting to a litre (33.8 f℥).

Process. Place 100 c. c. (27 f℥) urine, acidulated with 20 to 30 drops hydrochloric acid, and heat it in a water-bath. When boiling, allow 5–8 c. c. of the barium solution to flow in from a burette. Remove the heat and allow the precipitate to subside. If the fluid becomes rapidly clear, allow another cubic centimetre or two of the barium solution to flow in, reapply the heat and filter 10 to 12 drops of the urine into a small test-tube, add some of the barium solution, and observe whether there is a precipitate or not. If not, add to another portion a few drops of the potassium sulphate solution, by which we learn whether an excess of the barium solution has been added or not. If, however, the barium

solution still produces a precipitate in the portion removed for testing, the latter is returned to the beaker, and more solution allowed to fall in, determining the quantity somewhat by the intensity of the reaction in the test-tube, and the process repeated until no precipitate takes place with the barium, and until a *slight* cloudiness takes place when adding the potassium sulphate to a portion of the filtered mixture. If the latter is an intense reaction say at 12 c. c., then we know that the correct point is somewhere between 11 and 12, and the process is repeated as far as 11 c. c., when it is continued very cautiously, adding only fractions—$\frac{1}{10}$ths of a centimetre—until the right point is reached, whence the calculation is made as before.

URINARY DEPOSITS.

It has already been said that strictly normal freshly passed urine, of acid reaction, contains no sediment whatever, except the faint flocculi of mucus which gradually subside towards the bottom, and entangle a few mucus-corpuscles and an occasional epithelial cell. Should the urine, however, be alkaline, as is frequently the case three to four hours after a meal, it may be more or less cloudy at the moment it is passed, and quickly deposit a flocculent precipitate of *earthy* phosphates, which may occupy considerable bulk. They will be found by microscopic examination to be made up of amorphous granules, and will quickly disappear on the addition of a few drops of any acid.

But even urine which is strictly normal will, in the course of time, form deposits as the result of different reactions. These deposits differ with the stages of such reaction, and should be perfectly understood by the student before he is ready to interpret any sediment arising from other causes.

1. After normal urine, completely without sediment, has stood for a time, there is often observed a precipitate of amorphous granular matter, readily soluble by heat,

which is made up of acid urates of potash, soda, and ammonia, with which urates of lime and magnesia are occasionally commingled. (See lower portion of Fig. 10.) A little later they are replaced by rhombic crystals of uric acid, stained yellowish or yellowish-red. These are often associated with octahedral crystals of the oxalate of lime.

The explanation given by Scherer of the occurrence of these deposits, is that of the so-called *acid* fermentation, in which, through the agency of the mucus of the bladder, acting as a ferment, are formed *lactic* and *acetic* acids out of the coloring and other organic matters. These take away a part of the base from the neutral or alkaline urates, and produce first the more insoluble acid urates named above, which are deposited; later they combine with the remainder of the base also, and leave the crystalline uric acid sediment.

As though favoring this so-called acid fermentation, there are also often found at this stage in urine, spores of *torula cerevisiæ*—the yeast fungus—small, oval, transparent, structureless cells, to be again referred to. Further sufficient proof that such fermentation takes place is, however, wanting.

A much more satisfactory explanation of the occurrence of these deposits, has been offered by Voit and Hoffman,* who attribute the decomposition of the basic

* Neubauer and Vogel, Analyse des Harns, vi Aufl., 1872, p. 113, from Zeitschrift für Analyt. Chemie, Bd. 7, p. 397.

urates to the acid phosphate of soda, the excess of phosphoric acid playing the part of the acetic and lactic acid in the fermentation theory, and decomposing the alkaline urates in the same way and with the same results. They prove their position by an artificial production of the same results, by adding a solution of acid phosphate of soda to a solution of basic urates. The extent to which the reaction goes will depend upon the quantity of acid phosphate of soda present, and the length of time which has been permitted for the reaction to take place. It is possible also for the latter to begin at the moment of secretion, and to continue in the bladder, causing deposits of acid urates and uric acid to appear as "gravel" or "sand" immediately after the urine is passed. Such a condition would be pathological. According to these authors, a more rapid action of the acid sodium phosphate produces an amorphous precipitate, and a slower separates the crystalline uric acid. The more rapid reaction may be induced by a more abundant separation of the acid sodium phosphate or a greater concentration of the urine.

In the course of these changes, also, the acidity of the urine is diminished, and it may become neutral and even alkaline before the phenomena of the next stage to be described—the alkaline fermentation—set in.

2. After a still longer but variable period, which is shorter in warm weather and longer in cold, we have the

so-called *alkaline fermentation*, which is a real fermentation. This, in which decomposing mucus is also thought by some to be the ferment, is ascribed by Tieghem* to the action of a little torula, structureless, and without a cell-wall, which multiplies by budding, not at the surface but within the urine or at the bottom of the vessel, where it with the deposited salts forms a white sediment. In this fermentation we have the urea converted into carbonate of ammonia, as already explained, by the addition of two equivalents of water.† As the result of this conversion, the urine is rendered highly alkaline, and a further change in the character of the sediment takes place. At the very beginning of the reaction, when the urine may still be neutral or even weakly alkaline, the uric-acid crystals begin to dissolve and to change their form so as to become more or less unrecognizable, while

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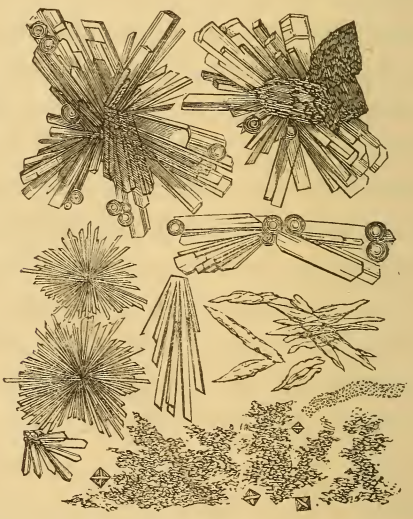
* Neubauer and Vogel, Analyse des Harns, vi Auflage, 1872, pp. 110 and 130.

† An explanation of the delay which sometimes occurs in the appearance of these phenomena is based on the recognition of the multiplication of these spores as the cause of the fermentation. If infusoria are simultaneously developed, the urea is more slowly converted, and if the surface of the urine happens to be covered with other plant vegetation, as is sometimes the case (mildew), the urine may remain acid for months in consequence of the interference with the access of oxygen, on the presence of which the spore is dependent for its growth and multiplication.

on their fragments may often be seen to adhere prismatic crystals of urate of soda and dark spheres of urate of ammonia. (Fig. 10.) As the reaction becomes alkaline,

FIG. 10.



Prismatic crystals of sodium urate, spherules of ammonium urate and amorphous urates with octahedral crystals of oxalate of lime. (Ranke.)

the uric acid altogether disappears, and the field becomes crowded with granules of amorphous phosphate of lime, beautiful triangular prisms ("coffin-lid" shaped crystals), and their modifications, of the triple phosphate of ammonia and magnesia, and opaque black balls of urate of ammonia often beset with spiculæ (Fig. 11); the spores referred to are also often present, while millions of

bacteria vibrate slowly along, or form granular aggregations about a fragment of organic matter, and an occasional infusorium darts across the field of view with magnified celerity. Commonly, however, the interme-

Fig. 11.

Spiculated spherules of ammonium urate along with octahedral crystals of the oxalate of lime. (Ranke.)

diate stage is lost sight of, and the stage just described is the only one seen in the alkaline fermentation. Such urine has an ammoniacal and putrescent odor, is cloudy from the suspended phosphate of lime and bacteria, and exhibits to the naked eye an abundant white deposit.

Either of the above set of changes may take place within the economy, in the pelvis of the kidney or in the bladder, and as such become pathological states which are constantly met with in practice, the first in the condition

of uric acid gravel or calculus with its incident suffering, and the second in the phenomena of irritation and inflammation, more particularly of the bladder, due to obstruction by stone, stricture or malignant disease. It also seems to be a matter of modern observation that the germs of the fungi above alluded to, which seem to have a very close relation to the phenomena described, either as cause or effect, may be introduced from without by the use of imperfectly cleansed catheters, sounds or similar instruments.

With this preliminary knowledge of the rationale of the causation of a large proportion of urinary deposits, we are ready to take up their detailed consideration.

Classification of Deposits. Efforts have been made to classify sediments on different bases, that is, on the ground of their external naked-eye characters as to bulk, color, weight, etc., again with regard to their nature and origin, whether organized or unorganized, crystalline or amorphous, and finally as to the reaction of the urine in which they are found.

The simplest division is into *unorganized* and *organized*. A further division of these groups into crystalline and amorphous, seems to separate groups which are naturally associated, and is therefore omitted.

I. UNORGANIZED.

1. Uric acid (crystalline).
2. Uric acid compounds.
   - *a.* Acid sodium urate (amorphous, occasionally crystalline).
   - *b.* Acid potassium urate (amorphous).
   - *c.* Acid calcium urate (amorphous).
   - *d.* Acid ammonium urate (crystalline).
3. Oxalate of lime (crystalline).
4. Earthy phosphates,
   - *a.* Ammonio-magnesian phosphate (crystalline).
   - *b.* Calcium phosphate (amorphous and crystalline).
5. Carbonate of lime (crystalline).
6. Leucin and tyrosin (crystalline).
7. Cystin (crystalline).

II. ORGANIZED.

1. Mucus and pus.
2. Epithelium.
3. Blood.
4. Pigment flakes.
5. Casts.
6. Spermatozoids.
7. Fungi and infusoria.
8. Elements of morbid growths.
9. Entozoa.

I. UNORGANIZED SEDIMENTS.

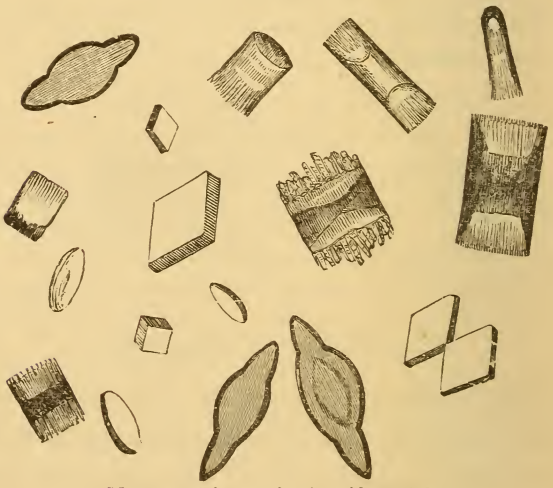
1. Uric Acid.—*Occurrence, etc.* Uric acid presents itself as a sediment of small bulk, sinking to the bottom, but sometimes adhering also to the sides of the glass. The individual crystals are often large enough to be seen by the naked eye, and in their aggregation often form masses so large as to be characterized by the terms "sand," "gravel," "red-pepper grains." This latter

term is based upon the *red* or *yellowish-red* coloration which uric acid crystals in urine exhibit.

They are found perfect only in acid urine, often at the end of the so-called acid fermentation, in urine concentrated from any cause, and where there is a pathological increase in the production of uric acid due to imperfect oxidation or assimilation.

Recognition. The typical shape of a uric acid crystal may be said to be a *four-sided* rhomb, and *six-sided* plate.

FIG. 12. (After Harley.)

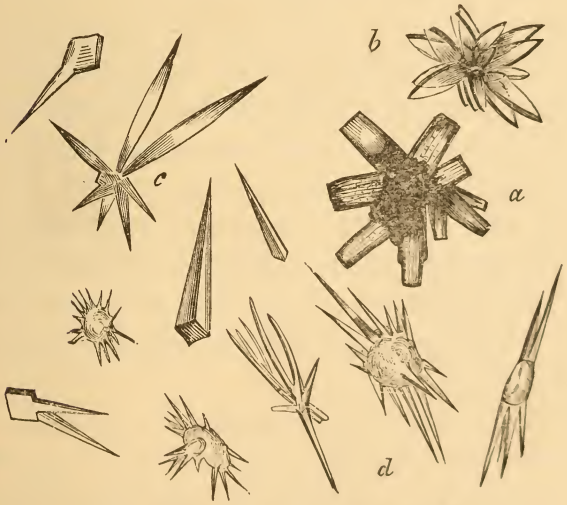


More usual forms of uric acid crystals.

But it is comparatively seldom that the typical forms are observed, the latter shape being somewhat rare, and the angles of the former being generally so rounded off that

the crystal assumes an ovoid or "whetstone" shape, of very different sizes, some being mere points with powers of 200 to 300 diameters, while others are large enough to be seen by the naked eye. Further shapes are those of sections of a barrel, envelope, spear, fan, of a comb with teeth on two sides, quadrilateral prisms with terminal planes, dumb-bells, and even other forms. What are commonly called "dumb-bells" of uric acid may be

FIG. 13. (After Harley.)



More unusual forms of uric acid crystals.

rather compared to a tuft of hay constricted at its middle. These varied forms, practice soon teaches one to recognize, even though they may deviate much from the

typical shape. Uric acid crystals as observed, are *almost invariably* colored, and can generally thus be distinguished from other deposits. Dr. Beale* states that two or three instances have come under his notice in which they were not colored. Uric acid crystals are met singly, but very commonly they are aggregated, forming beautiful rosettes and other shapes of aggregation of such size, as to be easily visible to the naked eye—as the "red-pepper grains" already alluded to—and to give pain in their transit through the ureter.

Fig. 12 exhibits the more usual varieties of uric acid, and Fig. 13 some of the rarer forms. (See pages 114, 115.)

Tests for Uric Acid. Whenever a crystalline deposit is of doubtful character, and suspected to be uric acid, if the latter, it will respond as follows:

1. Insoluble in cold or hot water, it will readily dissolve in the alkalies, soda, potash, or ammonia. If then the alkaline solution be treated with an excess of acetic acid, in a few hours typical whetstone-shaped forms will crystallize out.

2. Or the sediment may be placed on a glass slide, and treated with the murexid test as described on page 86.

The dumb-bell crystals of uric acid occasionally met with may be distinguished from the dumb-bell crystals

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* Kidney Diseases and Urinary Deposits, Philadelphia, 1869, p. 371.

of the oxalate of lime, by the characteristic shape already referred to, by their larger size, their darker color, and their solubility in alkalies.

2. Uric Acid Compounds. a. *Sodium urate*, mainly amorphous, is sometimes crystalline. It always forms a part, and, according to Bence Jones, a predominant part in the pulverulent, heavy, variously tinted, and generally bulky deposit of the mixed urates known as "brick-dust" or "lateritious" sediment. The degree of coloration of this sediment depends upon that of the coloration of the urine whence it falls. From pale urine of low specific gravity, 1010 to 1014, an almost *white* sediment separates, falling very slowly, and producing therefore an opaque, cloudy appearance in suspension, but readily disappearing on the application of heat; from urine of an amber color, and specific gravity of about 1018, the urates deposited are *fawn*-colored; and from high-colored urine of higher specific gravity, we have the true red "brickdust" sediment. The sediment is found in faintly acid urine, or urine in which the acid fermentation has only commenced, and has not been operating so long as completely to remove the base, and cause the crystalline uric acid to be deposited. It is found also in urine concentrated from any cause, or where it has cooled down considerably below 37° C. (98½° F.), or where there is defective oxidation or assimilation, as in fevers.

Recognition. By far most frequently do we find sodium

urate in fine amorphous granules, by their shape in no wise distinguishable from other fine granular matters, requiring therefore the chemical tests for their discrimination. The adhesion of these fine granules to partially coagulated shreds of mucus sometimes gives rise to an appearance resembling finely granular casts (see Fig. 10), which is readily detected by the experienced, but which may mislead the beginner. The careful application of heat, or the addition of a drop of acetic acid, will promptly dissipate the illusion. These granules of sodium urate also assume a larger size, and become little spherules, sometimes provided with spicules (see Fig. 11), which are considered by some (G. Bird, Beale) to be spicules of uric acid (Beale, Figs. 104 and 105, opposite page 354). Other spherules are provided with projecting and curved processes, and are believed by Hassall (second edition, page 75) and Thudichum (page 102) to be composed of urate of soda throughout. That the *spines* were also urate of soda, Thudichum considered evidenced by their solubility in water. A modified form of the latter is probably the irregularly star-shaped crystal in Dr. Beale's Fig. 110, from the urine of a patient suffering with peritonitis. But all of these forms of spherules with straight and incurved processes (thorn-apple shapes) are put down by the German observers (Neubauer and Vogel, Hoffmann and Ultzmann) as crystalline forms of urate of *ammonia*, in which I am inclined

to concur, at least with regard to those which are found at the stage of reaction intermediate between the acid and alkaline fermentations, or perhaps rather at the beginning of the latter, when ammonia makes its appearance, and is accompanied by the ammonio-magnesian phosphate. But any spherules which occur early in the acid reaction, or before it is possible for any ammonia to be present, are probably *sodium urate.*

The sodium urate is also rarely found in *dumb-bells* which are also striated and broad at the extremities like those of uric acid, but less disposed than the latter to break up at the extremities into individual acicles (Atlas of Hoffmann and Ultzmann, Taf. IX). One-half of one of these dumb-bells, viewed from above, would be fan-shaped.

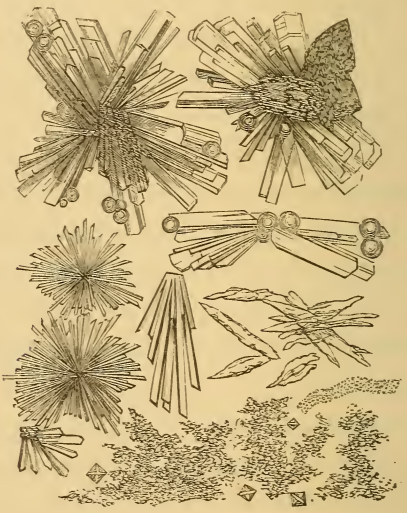
Under the same circumstances, at the end of the acid, and at the beginning of the alkaline fermentation, do we also have the true prismatic *crystals* of acid sodium urate, arranged in star-like masses (Fig. 14, p. 120).

b. *Acid potassium urate* is also amorphous, very soluble, and occurs under the same circumstances as sodium urate, as a constituent of the mixed waters.

c. *Acid calcium urate* occurs very seldom, and in small quantity, of white amorphous powder, along with the mixed urates. It is with difficulty soluble in water, and known to have lime for its base, by leaving a residue of calcium carbonate after incineration.

d. *Acid ammonium urate.*—*Occurrence.* This is found along with amorphous earthy phosphates and crystals of the triple phosphates of ammonia and magnesia, in urine

FIG. 14.



Prismatic crystals of sodium urate, spherules of ammonium urate and amorphous urates with octahedral crystals of oxalate of lime. (Ranke.)

in which the alkaline fermentation has commenced. It is the only urate found in alkaline urine.

Recognition. It is crystalline, and presents itself in the shape of smooth and the characteristic "thorn-apple" spherules (Figs. 10 and 11), which serve easily to distinguish them. They are dissolved in hot water, and dissolve with the evolution of uric acid crystals, by hydro-

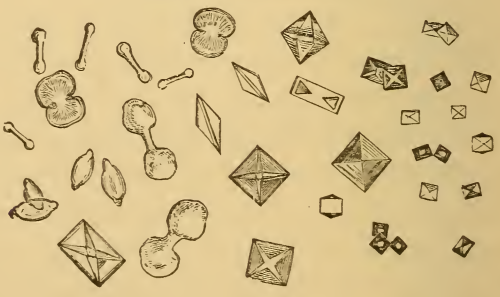
chloric or other acid. Liquor potassa, added to them, evolves the odor of ammonia, and they give the murexid reaction with nitric acid and ammonia.

Tests. Though the acid urates are much more insoluble than the neutral urates remaining in solution, requiring 124 parts of boiling water, and 1150 of cold, they readily dissolve on the application of heat to the slide or test-tube containing them. They are dissolved also by the alkalies, liquor potassa, or soda. Treated with nitric, hydrochloric, or acetic acids (the diluted are better on account of their slower action), they dissolve with the subsequent crystallization of uric acid. They also respond to the murexid test.

3. Oxalate of Lime.—*Occurrence.* The oxalate of lime crystals are most frequently met in acid urine, often therefore alongside of crystals of uric acid, but they may also be met in alkaline urine, along with crystals of the triple phosphate. They are particularly abundant in the urine after a meal of rhubarb plant, after the use of tomatoes, and other vegetables containing oxalic acid. There are no means by which the presence of oxalate of lime may be foretold before a microscopic examination of the urine is made. It never forms a deposit appreciable to the naked eye, and most commonly the crystals do not descend to the bottom of the glass, but are caught as it were by the flocculi of mucus which float *towards* the bottom, rather than occupy it.

Recognition. Two forms of oxalate of lime crystals are met, the octahedra and the dumb-bell crystals. The former appear somewhat differently according as they are seen in the longer diameter or in the shorter. They may be said to be made up of two four-sided pyramids, placed base to base, and when viewed in the longer diameter, may readily be detected as such by the microscope. When seen in the opposite direction, their characteristic appearance is that of a square, crossed obliquely by two bright lines, and if the crystal be very small, it will appear as a square with a bright point in the centre—a characteristic appearance by which one may soon learn to detect them, even when they are very small. They are often seen in aggregations of three, four, or more, closely adherent, and forming as it were microscopic calculi.

FIG. 15. (After Harley.)



The *dumb-bells*, very much more rarely met with, are highly characteristic, and although we have spoken of

dumb-bells of uric acid and of ammonium urate, neither of the latter present the typical dumb-bell appearance like those of the oxalate of lime. To these are found also allied forms, circular and oval shapes, with darker or brighter centres, and some with partial concavities at the sides, as though passing over into dumb-bells. Dumb-bells are also met with in the urine aggregated, forming microscopic calculi, which go far to explain the incipient formation of calculi.

Chemical Characters. The form of crystals of oxalate of lime is so characteristic, that there is seldom occasion to make use of chemical tests to determine them. The only crystals which at all resemble them, are certain forms of the triple phosphate. These are small crystals, modifications of the typical triangular prism, with its bevelled ends, in which the body of the prism is exceedingly short, or as it were almost left out, so that the two inclined triangular ends closely approach each other, and form a crystal like that of the octahedron of oxalate of lime. Their nature may, however, be suspected by the character of the larger crystals around them, for they never occur alone. Moreover, they are promptly dissolved by the addition of acetic acid, while the oxalate of lime is totally insoluble in this acid. The octahedra are highly insoluble in water, in alkalies, and in the vegetable acids, including acetic, but are soluble in the mineral acids. The dumb-bells, after a prolonged action

in acetic acid, yield their crystalline matter, leaving a framework, which maintains the original shape of the crystal. This in fact explains, perhaps, the shape of the crystal. It has been shown by Mr. Rainey and others, that the presence of organic matter, as mucus, interferes with crystallization in the regular manner. The dumb-bells of oxalate of lime can readily be distinguished from the dumb-bells of uric acid or urates by the solubility of the latter in alkalies.

The acid phosphate of soda, according to Neubauer,* possesses a power of solution over the oxalate of lime, often holding it in solution, and he gives a method by which the latter may be obtained from solution in the urine by its agency, as follows: 4 to 600 c. c. (108 to 162 f℥) of the urine to be tested is treated with solution of chloride of calcium, supersaturated with ammonia, and the precipitate dissolved in acetic acid. After twenty-four hours, the precipitate arising, which nearly always contains uric acid, is placed on a filter, washed with water, and a few drops of hydrochloric acid poured upon it. The latter dissolves out the oxalate of lime present, and leaves the uric acid on the filter. The filtrate is then diluted in a test-tube with 15 c. c. (2.83 f℥) of water, and overlaid most carefully, by means of a pipette, with very dilute ammonia in sufficient quantity. At rest, the

* Neubauer and Vogel, op. citat, p. 174.

two fluids gradually mingle, and after twenty-four hours the oxalate of lime present will have collected at the bottom, and octahedra of great beauty may be studied with the microscope.

Neubauer says he has many times, in this manner, obtained considerable quantities of oxalate of lime, where there was previously no deposit whatever. He has, however, in other instances with normal urine, obtained negative results, so that he is unable to decide whether oxalate of lime should be considered a normal or abnormal constituent of urine.

There is no doubt but that *oxalic acid* is at times, at least, secreted by the kidneys, and meeting immediately the lime salts for which it has a strong affinity, forms the crystals we are considering; for both octahedra and dumb-bells are not infrequently found in the uriniferous tubules of the kidney and even in tube-casts. Schunck has attempted to show that the oxalate of lime is formed during the decomposition of urine from the oxalate of ammonia, but Neubauer says the oxalate of ammonia is converted into carbonate of ammonia. Others, as Owen Rees, Aldridge of Dublin, Wöhler, and Frerichs, allege that oxalate of lime is derived from a decomposition of uric acid and urates. Their experiments would seem to show this, and it is undoubtedly the case that deposits of oxalate often make their appearance in urine some time

after it has been passed. Two sources must, therefore, be admitted, one within the organism and one without.

Clinical Significance. There is no disease with which the oxalate of lime is particularly associated, nor can deposits of it be considered indicative of derangement. Abundant deposits of oxalate of lime are found in the urine of persons who are typically healthy. On the other hand, it is apt to occur where there is mal-assimilation, and hence dyspeptics are often found having oxalates in their urine, as a result rather than a cause of the affection from which they suffer.

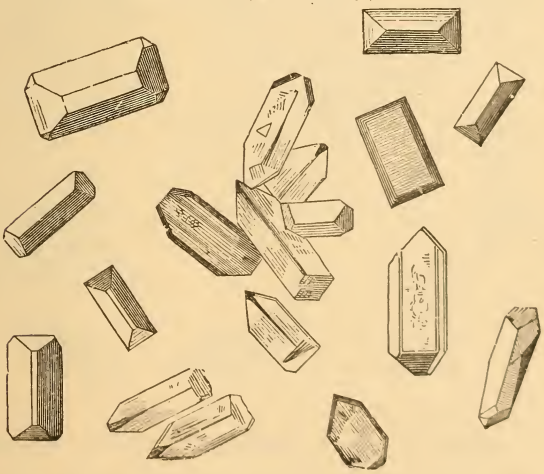
When there is evidence of renal calculi in descent from the pelvis of the kidney, and oxalates are found in the urine, especially if they are found in the aggregations referred to, the latter may afford explanation of the nature of the stone. Unfortunately, too often there is no sediment whatever attending the descent of a calculus, and we must, therefore, determine its nature without such aid. A careful examination should, however, always be made of the urine in nephritic colic, as valuable information is at times at least furnished by it, especially in the uric acid lithiasis where uric acid sediment is often found.

4. EARTHY PHOSPHATES.— *Occurrence.* These deposits are found only in very feebly acid or alkaline urine, and are the more abundant, the more advanced is the stage of alkaline fermentation. They appear to the naked eye as

bulky opaque white deposits, unless they are accompanied by blood, which then more or less tinges them. The urine itself is apt to be turbid from the presence of amorphous phosphate of lime in suspension, to have an ammoniacal and sometimes a fetid odor, though not necessarily. They are especially abundant in the urine of all irritative affections of the bladder, and often attend diseases of the spinal cord. The earthy phosphates are the *triple phosphate* or ammonio-magnesian phosphate and the *phosphate of lime.*

a. The Ammonio-magnesian Phosphate ($MgNH_4PO_4$

Fig. 16. (After Harley.)

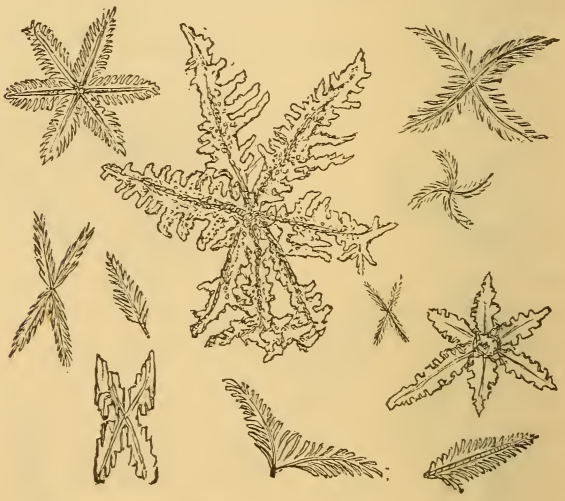


$6H_2O$), or triple phosphate, is a crystalline deposit, of which the typical form is a triangular prism (Fig. 16)

with bevelled ends, very characteristic and easily recognized.

In addition to this, there is an infinite variety of modifications, with one or more corners removed, the body of the crystals variously shortened, etc. Among these forms is the small crystal already referred to as being possibly mistaken for the oxalate of lime. There are also sometimes found beautiful star-shaped (Fig. 17) crystals of

FIG. 17. (After Harley.)



triple phosphate, which gradually undergo conversion into the prisms, and between these two there are many intermediate forms.

b. Phosphate of Lime, amorphous $Ca_3(PO_4)2$; crystal-

line $CaHPO_4$. Phosphate of lime is most frequently found amorphous under the same circumstances under which the triple phosphate is found. It is, however, frequently deposited from normal urine in which it is held in solution during the acid reaction by the acid phosphate of soda, or carbonic acid, or by both. At any rate let the acid reaction be wanting, as it is three or four hours after a meal, and a copious deposit of calcium phosphate often takes place, which is increased by boiling. In other instances, a urine may be acid in its reaction, and the boiling, apparently by driving off the carbonic acid, will cause the phosphate to go down. These deposits have more than once been spoken of as possible sources of error in testing for albumen, but they promptly disappear on the addition of acids. The color of the phosphate of lime alone is not snow-white as that of the triple phosphate, but rather yellowish.

Not infrequently we meet in urinary deposits *crystalline phosphate of lime* (Fig. 18), which occurs sometimes alone and sometimes along with the triple phosphate. It is also met in urine of a weak acid reaction, but strongly disposed to take on the alkaline fermentation. The occurrence of crystalline phosphate of lime seems peculiar to certain individuals, and Hoffmann and Ultzmann have met persons perfectly healthy, who, in the summer months, have almost daily deposits of crystalline phos-

phate of lime. They are frequently associated with octahedra of the oxalate of lime.

FIG. 18.

Crystalline and amorphous phosphate of lime.

Recognition. The isolated crystal of phosphate of lime may be said to be *wedge-shaped* or even *conical*, from which form there are, however, variations. But their characteristic feature is in their arrangement, which is that of a circular rosette, in which the apices of the numerous crystals forming it all point to the centre. Phosphate of lime is also found in the shape of spherules

or even *dumb-bells*. The latter are said by Dr. Beale (Kidney Diseases and Urinary Deposits, p. 357) to be deposited in decomposing mucus, not only from the urinary tract, but from other surfaces, as the gall-bladder. Dr. Beale figures such dumb-bells in his Plate xxi, Figs. 116 and 118.

Chemical Characters. All of the phosphates are dissolved by acids, but are insoluble by alkalies and heat, whereas the uric acid salts are dissolved by both these agencies. The small triple phosphate crystals, which resemble those of oxalate of lime, dissolve quickly in acetic acid, while the octahedra are untouched by it. Uric acid itself could scarcely ever be confounded with phosphates, occurring, as it does, in urine of different reaction; but if it were necessary to discriminate them, the former are dissolved by alkalies, the latter not. Moreover, the murexid test will not respond to phosphates, but will to uric acid.

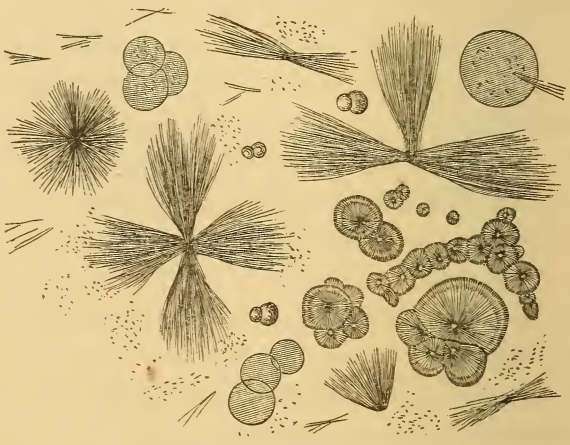
5. Carbonate of Lime is a very rare deposit in human urine, but found abundantly in horse's urine. When present, it occurs in small spheres, and is detected by its effervescence with acetic acid.

6. Leucin and Tyrosin.—*Occurrence.* These crystalline deposits are only found in urine which is loaded with biliary coloring matters, since they attend only grave destructive diseases of the liver, especially acute yellow atrophy and phosphorus poisoning.

Recognition. If suspected in urine presenting the above characters, it may be slightly evaporated, when the crystals will be deposited if present.

Leucin presents itself in the shape of more or less yellow-tinged, highly refracting spheres, which may at first sight be taken for *oil-drops.* A little study will show them refracting light not quite so strongly, *i. e.*, not possessing quite so wide a dark border; and by suitable illumination, many of them will be found marked with

FIG. 19.



Leucin spheres and tyrosin needles.

radiating and concentric striæ. The spherules further exhibit a peculiar disposition to aggregate, appearing partially to merge where two edges come together.

Tyrosin is found in the shape of very fine needles

arranged in tufts or "*sheaf*"-like collections, often crossing each other and intersecting at their constricted central portions (Fig. 19).

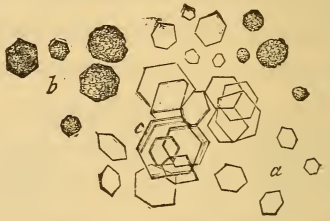
Chemical Characters. *Leucin* spheres, unlike oil-globules, are insoluble in ether, and further are soluble in caustic alkalies, but not in cold mineral acids. *Tyrosin* may be recognized by Hoffmann's test. A suspected deposit is boiled in an excess of water. To the boiling fluid, a few drops of a solution of mercuric nitrate are added, and there arises a red precipitate, while the supernatant fluid is colored red to purple-red.

7. Cystin ($C_3H_7NSO_2$).—*Occurrence and Recognition.* Cystin is a rare urinary sediment. Crystalline, forming a whitish or dirty yellowish-gray deposit, which on microscopic examination is found to be made up of regular six-sided tablets of different sizes, often so arranged that one of smaller size is superimposed on one of larger, and this upon a still larger, and so on; but it also occurs in irregular masses (Fig. 20). It is usually met in a pale urine, both acid and alkaline, developing in decomposition the odor of sulphuretted hydrogen, as well as that of ammonia, the former doubtless derived from the sulphur contained in the cystin. It occurs as a separate urinary deposit as well as accompanying cystin calculus, which seems sometimes to be hereditary.

Chemical Characters. It is soluble in ammonia, and by this property may be distinguished from similar six-

sided crystals of uric acid, which not unfrequently accompany it. Upon spontaneous evaporation of the ammoniacal solution, the six-sided crystals reappear, showing that it is simply dissolved in the ammonia, and not in chemical combination with it. It is also soluble in acetic, and solution of oxalic acid, while uric acid is uninfluenced

FIG. 20. (After Harley.)



by them. It is soluble in potash, and insoluble in solution of carbonate of ammonia, and therefore may be precipitated from an acid urine by the alkaline fermentation; under these circumstances it would be accompanied by amorphous phosphate of lime and crystalline phosphate of ammonia and magnesia, with neither of which is it likely to be confounded. In a mixed deposit containing six-sided crystals, the lime and triple phosphate may be dissolved out with acetic acid, while the plates of cystin will remain. They may then be treated with ammonia and hydrochloric acid, to distinguish them from uric acid.

II. ORGANIZED DEPOSITS.

1. Mucus and Pus. Mucus, even if present in considerable amount, could not be recognized by its own properties, it is so transparent and similar to urine in its refractive index. It is visible only through the accidental morphological constituents which it more or less constantly holds in suspension. These are the so-called mucus-corpuscles and epithelium from all parts of the genito-urinary tract, as well as crystals of the oxalate of lime, granules of sodium urate, and even crystals of uric acid. In strictly normal urine the first two would alone be present, and in very minute quantity. These cause mucus to appear, when present in normal amount, as a *delicate* cloud, often barely visible, floating *towards* the bottom rather than at the bottom of the vessel.

By the action of *acetic* acid, the *mucin*, an element of mucus which is comparable to albumen, though not coagulable by heat, is precipitated in the shape of delicate fibrillated bands, which are sometimes tortuous, and again appear as delicate threads known as mucin threads. If a little iodine and iodide of potassium be added to such acetic acid, they are made even more distinct. Tartaric acid and very dilute solutions of the mineral acids have the same effect, while an excess of the same will redissolve the precipitate; so too the mineral acids will dissolve the coagulum of acetic acid, while an excess of the

latter will not dissolve it. These coagula may sometimes be found in urine to which no acids have been added, being probably produced by the action of the acids developed in the acid fermentation. Under these circumstances they are particularly apt to be studded with granular urates, which may cause them to be mistaken for granular tube-casts, but they are generally very much narrower than the latter, and the addition of a little warmth, hydrochloric acid or alkali will quickly dissolve the granules. (See Fig. 10.)

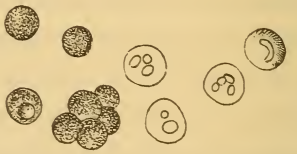
As the result of irritation of any part of the genito-urinary tract, mucus is increased in quantity, when it assumes a thicker more ropy character, and becomes more or less opaque, but even here the opacity is due to the increased proportion of cellular element rather than to the mucus itself, which is always transparent. Under these circumstances, the opaque clouds of mucus are often enormously increased, and with them the adherent epithelial cells from the seat of irritation. When thus in excess, mucus is apt to pervade more or less the entire mass of the urine rather than sink to the bottom, giving the entire fluid, therefore, a glairy character. Mucus, however, seldom becomes very abundant without being attended by pus, as the causes producing them are but differences of degree. So long, however, as urine containing mucus is without *albumen*, so long may pus be said

to be absent, as *mucus itself contains no albumen, while pus does.*

The Mucus- and Pus-corpuscle. The *mucus-corpuscle,* as it appears in urine, is a small, granular, spherical or nearly spherical cell, rather larger than a blood-corpuscle, that is .008 to .010 millimetres ($\frac{1}{3000}$ to $\frac{1}{2500}$ of an inch) in diameter, containing one or more nuclei. In a healthy condition of mucous membrane, a mucus-corpuscle, however it originates, is nothing more nor less than a young epithelial cell which has been pushed off before it has attained the characters of such cell in its development. As such, therefore, we must not too closely restrict its size, for who shall say where the mucus-corpuscle terminates and where the epithelial cell begins? As such a young cell, without morbid impression, simply arrested in its normal development, a single nucleus is more common than it is in the *pus*-corpuscle, of which the multiple nucleus may be said to be more characteristic. But here the difference ceases. For the pus-corpuscle, when young (that is, not the subject of fatty degeneration), is a cell exhibiting the same characters, and may be defined in the same way. The fact being that when a cell exhibiting the above characters, with one or multiple nuclei, is found upon a non-suppurating surface, it is called a mucus-corpuscle, while the same cell on a suppurating surface would be called a pus-corpuscle. Thus, while the two are physiologically distinct, they are anatomically

the same, the physiological difference being in this, that a pus-corpuscle is a cell too rapidly produced to be allowed to develop into the normal tissue of the part, while the mucus-corpuscle is, as it were, only accidentally arrested in its development. The same resemblance which exists between these bodies, exists between them and the white corpuscles of the blood, and to the whole class of cells to which the term *leucocyte* or white cell is conveniently applied.

FIG. 21.



Mucus- and pus-corpuscles before and after the addition of acetic acid.

The Action of Reagents. The mono-nucleated mucus-corpuscle, which may be considered an older mucus-corpuscle, or young epithelial cell thrown off at a later period, usually exhibits its single nucleus distinctly, without the addition of a reagent; but the majority of leucocytes have not their nuclei visible until acted upon by certain reagents, of which two acting similarly most interest us. These are water and dilute acetic acid.

1. *Action of Water.* When water is added to the pus- or mucus-corpuscle, its first effect is to cause the latter to swell up, sometimes to twice the original size, next to

become smooth, the granules gradually disappearing, while the nuclei come forth with great distinctness. Finally, after some time the body of the cell becomes almost and then quite invisible, while the nuclei remain some time longer. The circumstances under which the corpuscle exists in urine are not quite identical, because in it we have a solution of organic and inorganic matters considerably denser than water, sp. gr. 1015 to 1025, and while the action is somewhat similar, it is very much slower; and if the specific gravity of the urine should be very high, exceeding that of the fluid in the cell, there might be no effect or a contrary one, *i. e.*, a shrinkage of the cell from an exosmosis of its contents.

2. *Acetic Acid.* The action of dilute (20 per cent.) acetic acid is identical with that of water, except that it is very much more rapid, and the stage of distinct nuclei is reached much sooner.

3. The *caustic alkalies* have a rapidly destructive effect upon these corpuscles, destroying their morphological identity, and converting them into a gelatinous adherent mass.

Urine containing pus deposits an opaque white sediment, which sinks rapidly to the bottom, so long as the reaction is acid and there is no mucus present. Such urine, when shaken up, becomes more or less opaque, according to the amount of pus which it contains. The opacity, as well as the deposit, often resembles that due to the pale granu-

lar urates, from which it is distinguished by the disappearance of the latter on the application of heat, while *purulent urine deposits* albumen under the same circumstances. To a less degree does urine containing pus resemble that containing amorphous phosphate of lime, but the latter is dissipated by acids, while acids also precipitate the albumen from pus, and the microscope reveals millions of the granular cells already described as pus-cells, in many of which the nuclei are already displayed in consequence of the action of water.

Donné's test for pus is based upon the reaction referred to between the alkalies and pus. It consists in the addition of liquor potassa to the deposit of pus after the supernatant urine is poured off. If the deposit is pus, it is promptly converted into a viscid gelatinous substance *resembling mucus*, which adheres to the bottom of the test-tube, often permitting its inversion without falling out, and which, when it is forced to flow, does so in a continuous mass as the albumen runs out of a broken egg. If a portion of this glairy mass be examined under the microscope, the pus-corpuscles will be found to have been destroyed, or rather converted into the substance itself. If the action has not been very long, or the proportion of alkali to the pus is small, the nuclei of the corpuscles may still be found as black dots in the mass, or a certain proportion of the corpuscles may preserve their integrity.

On this same reaction is based a most important change which urine containing pus undergoes after the alkaline reaction has set in. Through the agency of the carbonate of ammonia generated, precisely the same change is wrought, and the urine contains a deposit so closely adhering to the bottom of the bottle that it is impossible to remove it with a pipette. It must be remembered that *this is not mucus*, although it so closely resembles it, and although microscopic examination may show the total absence of pus-corpuscles. These have been destroyed by the alkali. Care should be taken, therefore, to determine the reaction of the urine before a mucoid deposit is decided upon, and if it is alkaline, another of acid reaction should be obtained. The glairy product referred to will be found dotted with glistening points, which on microscopic examination prove to be crystals of triple phosphate, while the supernatant fluid will be found to contain albumen, which is wanting in deposits of pure mucus.

Frequently in diseases of the bladder, these changes take place within the organ, forming a gelatinous mass, which plugs up the urethra and makes it almost impossible to evacuate the bladder, thus greatly increasing the suffering of the patient. In such cases the only remedy is to wash out the bladder with weak acid solutions, and having cleansed it, keep it so by their daily use. Even

when acid at the time of being passed, these urines become rapidly alkaline afterwards.

Sources of Pus in the Urine. Pus in the urine may come from any part of the genito-urinary tract. When descending from the *pelvis* of the kidney, as it often does, in impacted calculus, it is less apt to be mingled with mucus, the urine retains its normal reaction, and the pus is, therefore, readily miscible with the urine, and as promptly deposited from it. When coming from the *bladder*, if the urine is not already alkaline, it is apt to become so very quickly, and we have then the phenomena described as incident to the alkaline fermentation, taking place soon after the urine is passed, if not in the bladder itself.

In diseases of the *prostate*, are apt to be found long plugs of mucus, which, upon microscopic examination, will be found made up of aggregated pus-corpuscles, in which are sometimes found the larger round or nearly round nucleated cells peculiar to this seat. Similar plugs are found in the pus from gonorrhœa, and it is said also (Neubauer), that in this affection the mucus-corpuscles are distinguished from those derived from the bladder by their larger size, their "glass-like clearness," and diminished granulation.

In females pus is apt to obtain in the urine from leucorrhœa or other purulent discharge from the vagina. This should not be forgotten.

2. Epithelium. Epithelium from all parts of the genito-urinary tract is found in the urine, but it is not very often that we are enabled to locate its site beyond the bladder and vagina, partly, because of the comparatively slight differences in the epithelium from certain locations, and partly, because maceration in the urine renders such feeble distinctive points much less so.

Three varieties of epithelium may, however, be distinguished in urine, with tolerable ease: 1st, round cells; 2d, cylindrical or conical and spindle cells; and, 3d, squamous cells.

a. Round epithelial cells (*a*, Fig. 22) arise from the uriniferous tubules, particularly in their convoluted portion, from the deeper layers of the mucous membrane of the pelvis of the kidney, of the bladder, and of the male urethra. Some of these cells, originally somewhat flattened by pressure, swell up in the urine, and become nearly round. They are distinguished from pus- and mucus-corpuscles by their larger size and their *single* nucleus, which is distinct without the use of reagents, while the *multiple* nucleus of the pus-cell requires the use of acetic acid to exhibit it. There is no way of distinguishing the source of these cells more precisely than above, except that if the urine be albuminous, and there is evidence of renal disease, we presume them to come from the tubules of the kidney, or from the pelvis if there are symptoms of impacted calculus; otherwise from the urethra, the pros-

tate, Cowper's or Littre's glands, but cells from the latter are rare. If the plugs already referred to, made up of pus-cells with a few larger nearly round and distinctly mononucleated cells united by mucus, are present, we may infer the round cells to be from the epithelium

FIG. 22.

a, round epithelium from the bladder.
b, columnar " " ureter and urethra.
c^1, " " deeper layers of epithelium of bladder.
c^2, squamous " " superficial " " "

of the prostate. The round cells from the bladder are considerably larger than those from other sources—twice the diameter of a pus-cell.

b. Columnar or conical and spindle cells (*b*, Fig. 22) are derived, the first, from the superficial layers of the pelves of the kidney, from the ureters and urethra, the latter from the ureters and urethra.

c. The scaly epithelial cells (*c*, Fig. 22) arise from the bladder or the vagina. These are flat, but often thicker at the middle, contain a single nucleus, are irregularly polygonal in outline, and often turned over on themselves either completely or partially. The epithelial cells of the bladder (c^1) are not generally as large as those of the vagina (c^2) nor so flat; they are less apt to occur in layers or flakes, although also found thus. Frequently it is impossible to distinguish the two.

In acid urine these cells remain a considerable length of time, but in alkaline urine they are gradually destroyed, becoming at first swollen and more transparent.

3. Blood-corpuscles get into the urine from the tubules of the kidneys, from the pelvis, the bladder, the prostate, and from the uterus and vagina in their various physiological and pathological hemorrhages. They may be so abundant as to be easily distinguished in mass by the naked eye, or they may require the microscope for their detection. Urine containing blood in large amount, is impressed with the red color of the latter, but containing the moderate amount most frequently encountered in urine, it obtains a color depending on its reaction. If

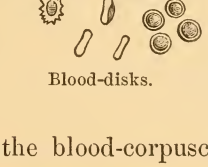
the urine is acid, it assumes a peculiar blackish-brown color which has long been described as "smoke-hued," and which is so characteristic as to enable one who is at all experienced, to decide at once as to the presence of blood. If, on the other hand, the urine is alkaline in reaction, it assumes the bright red color of blood. *Urine containing blood in any appreciable quantity, is albuminous.*

If blood-corpuscles are present in an amount sufficient to produce an appreciable deposit, they form a brownish-red pulverulent mass at the bottom of the vial if they come from the kidneys or ureters. They are more apt to be found in coagula, if they come from the bladder or urethra, though this latter is not necessarily the case; for, on the other hand, moulds of clotted blood are sometimes discharged from the ureters with all the agonies of nephritic colic.

Recognition. Blood-corpuscles are recognized under the microscope by the optical properties due to their biconcave centres. This is the *reversal of light and shadow* which they undergo in focussing, the centre and periphery alternating in brightness or shadow as the object-glass is approximated or removed from the slide. This, in connection with their evident biconcavity when seen on end, and their yellowish color, will always serve to distinguish them, although the effects of long continued maceration serve to interfere in different degrees with the distinctness of all of these features. If the urine is a

dilute one, the corpuscles will swell up, become biconvex instead of biconcave, finally spherical, and the reversal of light and shadow no longer occurs, while the coloring matter is more or less dissolved out. Ultimately the corpuscle altogether disappears. If, on the other hand, the urine is highly concentrated, the concavity becomes more marked and more distinctive, while the corpuscle itself shrinks and becomes smaller, and soon acquires the crenated or horse-chestnut shape (Fig. 23).

FIG. 23.



Blood-disks.

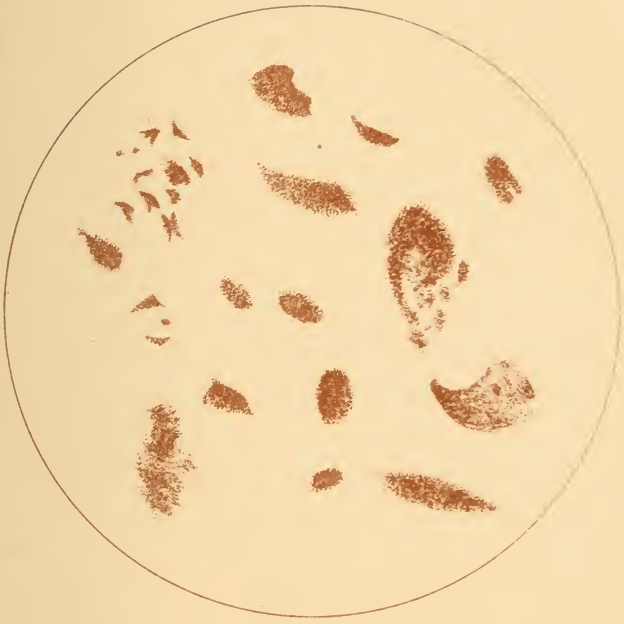
In an acid urine the blood-corpuscles maintain themselves for a long time, but in an ammoniacal urine they are soon dissolved, being soluble in alkalies. The hæmatocrystalline and hæmatin are then dissolved in the urine, and may be tested for as already directed.

4. CERTAIN PIGMENTED MARKINGS, COMMONLY CALLED "PIGMENT FLAKES" OR "PIGMENTARY PARTICLES." At this point it may be well to refer, by way of precaution, to certain appearances which have been variously designated, but to which the above terms have been most frequently applied.

No objects are more constantly met with, and none about which explanation is so often asked by the student as these, and yet no description of them seems to have been published before that of Dr. Roberts in his work on "Urinary and Renal Diseases."

Their appearance is that of little pigmented flakes which may be roughly compared in outline to squamous epithelial cells, such as come from the cutaneous epiderm, and have soaked a little while in water; yet while they are well-defined throughout most of their periphery on one side, they generally shade off and become gradually invisible. This may be due to the distribution of the reddish-brown granules, which are generally more closely placed in one part, being so numerous as to make the flake opaque or nearly so; from this they shade off in the manner described, disappearing altogether as the edge is approached. At other times the flake is filled throughout with pigment, when it appears dark, almost opaque, and equally well defined on all sides. The size of these "flakes" or "particles" is very various, from .008 millimetre to .025 millimetre ($\frac{1}{3000}$ to the $\frac{1}{1000}$ of an inch); the majority, and those which usually strike the attention, are of the latter size. (See Plate.)

Strange as it may seem, the appearances are nothing more nor less than stained "markings" or "fractures" upon the glass. This was only recently pointed out to me by my friend Dr. J. G. Richardson, and I have since



PIGMENT FLAKES.

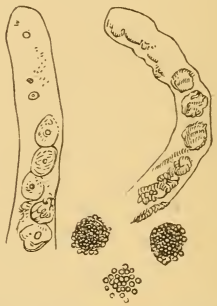
amply confirmed the observation. I had myself often recognized and demonstrated markings of similar contour on glass, but these were not pigmented; and the first conclusion to which Dr. R. and myself came was that the pigment flakes were the same scratches which had become filled with the coloring matter of blood or other substance which could not be removed by ordinary wiping and cleaning; but a trial with potash on the one hand and nitric acid on the other failed equally to remove them. What they precisely are, therefore, I do not as yet know; but their real nature thus far determined, there now appears abundant reason why it might before have been suspected, among which is pre-eminent the constancy of their occurrence, whatever the object examined.

5. Tube-casts. Tube-casts are moulds of the uriniferous tubules produced by an admission into the latter, by capillary rupture or otherwise, of a coagulable constituent of the blood, which there solidifies, and in this act entangles whatever it may have surrounded in its liquid state; subsequently it contracts and slips out of the tubule into the pelvis of the kidney, whence it is carried to the bladder and voided with the urine.

The mechanism of the production of the different varieties of casts is very simple. Thus, suppose a tubule to be filled with detached and loosely attached epithelium at the time the fibrin is poured into it. These elements are entangled, and as the cast contracts, carried out in the

shape of an "*epithelial*" cast (Fig. 24). If the tubule should happen to have contained blood, the cast entan-

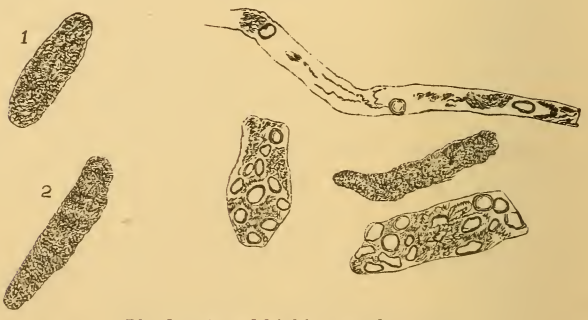
FIG. 24.



Epithelial casts and compound granule-cells.

gling it is called a "*blood-cast*" (Fig. 25). Casts containing even a few blood-corpuscles are also called blood-

FIG. 25.

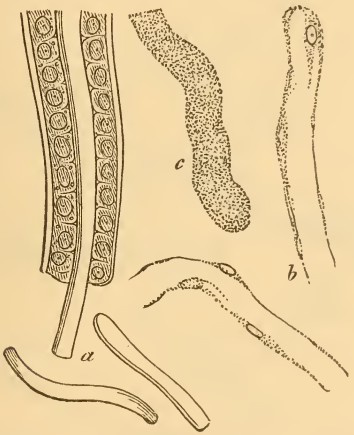


Blood-casts and highly granular casts.

casts. If the epithelium be firmly attached to the basement-membrane of the tube, and remain behind when

the cast passes out, or if the tube be entirely bereft of epithelium, then is the cast a "*hyaline*" (Fig. 26), or structureless cast. In the former instance the cast is of *smaller* diameter, and in the latter of *larger*, the diameter in the latter being that of the former plus twice the thickness of an epithelial cell. Fig. 26 from Rindfleisch ex-

FIG. 26.

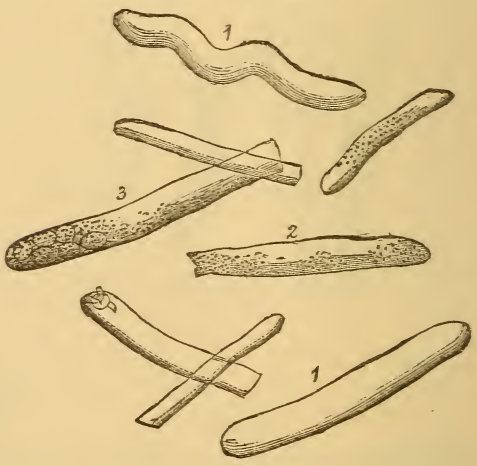


Hyaline and granular casts illustrating the formation of the former at *a*.

plains this sufficiently. A cast is seldom completely hyaline, generally containing a few granules and one or two glistening oil-drops, but it is still called *hyaline*. Completely hyaline casts do, however, occur. A variety of hyaline cast, more solid in appearance and resembling molten wax, is spoken of as a "*waxy cast*" (Fig. 27, 1). Some hyaline casts are so delicate as to be overlooked,

unless the light from the mirror illuminating the field of view be modified by shading with the hand or by manipulation of the mirror itself. If a cast contains granular matter, which is generally the granular débris of a degenerated epithelial lining of a tubule or of blood-

FIG. 27. (After Harley.)

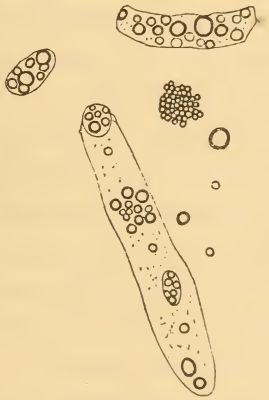


corpuscles, it is called a "*granular*" cast, and *highly* granular (Figs. 25 and 26), *moderately* granular (Fig. 26, *b*), *slightly* or *delicately* granular, according to the amount of granular matter present. When the material of granular casts is derived from broken-down blood-corpuscles, the casts appear yellow or yellowish-red. Finally, if a cast is loaded with oil-drops, either free or

contained in epithelial cells, it is called an "*oil-cast*" or *fatty cast* (Fig. 28).

Casts of smaller diameter are sometimes found within those of larger, the material of the latter having been poured out around that of the former after it has undergone some contraction. This occurs usually with waxy or hyaline casts. In consequence of the mode

FIG. 28.



Oil-casts and fatty epithelium.

of formation above referred to, hyaline and waxy casts vary considerably in diameter, some being as narrow as the .025 millimetre ($\frac{1}{1000}$th of an inch) and even narrower, while others are as much as .05 millimetre ($\frac{1}{300}$th of an inch) wide. There is no doubt but that some of these are formed in the straight or collecting tubes

near their openings on the papilla. To these a limited number of epithelial cells is sometimes attached.

In addition to the epithelial casts above described, there are found in urine under the same circumstances moulds of the uriniferous tubules made up of simple *aggregations* of the *epithelial cells themselves*—simple exfoliations of the cellular contents of the tubule, which having increased by proliferation form a compact cellular mass, which may be called "epithelial cylinders." In addition to these also are sometimes found epithelial casts in which the cells are seated on the outside or around the fibrinous mould.

Mucus-Casts. Casts are occasionally found, which are apparently pure *mucus-moulds* of the uriniferous tubules. Unless covered by accidental elements, as granular urates or phosphate of lime, they are smooth, hyaline or gently fibrillated moulds, especially characterized by their great length, which is often enormous, in the course of which they divide and subdivide reducing in diameter as the division proceeds, showing positively that they come from the kidney. Yet there is no albumen or merely as much as could be accounted for by the presence of pus which sometimes attends them. For they are particularly apt to occur where there is irritation of the bladder, which is apparently extended through the ureters to the kidney. Under these circumstances, I have met them on two or three occasions. Dr. Beale says (Kidney Diseases,

etc., p. 342), they are not unfrequently passed in cases where the urine has a very high specific gravity, 1030 or higher, containing an excess of urea and urates.

These casts are not identical with the bands of mucin already alluded to, p. 136, which are found in the urine of highly acid reaction, perhaps precipitated by the acids, which are often beset with granular urates, and might be mistaken for casts.

Casts of the seminal tubules are sometimes found in the urine, but their origin may be inferred from the presence of spermatozoids in them.

To Prepare Urine for Examination for Casts. The greatest caution should be exercised in examining urine for casts. They are often so sparsely present as to furnish no deposit appreciable to the naked eye, and yet may be found by careful microscopical examination. While it is not impossible for non-albuminous urine to contain casts, yet I have never met them, except perhaps in a single instance, where albumen and casts having been present, in their gradual disappearance the signs of the presence of albumen disappeared before the last casts had been washed out. On the other hand the presence of albumen means casts in the vast majority of instances, and many times I am certain they are declared absent, simply because they are not carefully sought. Not a single slide should satisfy the examiner, but two or three should be carefully studied throughout their

entire field. Nor is a plain slide sufficient. Urine should be examined in shallow cells, and as those of thin glass are generally too deep, the best are made with gum-dammar or Bell's cement, by means of a turntable and brush, since in this way they may be obtained sufficiently shallow to allow them to be penetrated by an ordinary one-fifth or one-fourth objective. After being made they should be put away for a month or more to thoroughly dry and harden, else they are washed off with the first cleaning of the slide.

Most casts from their lightness subside slowly, and the more so because the urine is albuminous. As soon as received, therefore, the bottle of urine should be shaken up, poured into a conical glass, and carefully covered. Although casts generally fall to the bottom in a shorter time, I have known twelve hours to elapse before one could be discovered, and therefore whenever it is possible, urine should be allowed to stand for this time in a conical glass, and examined the next morning. If the urine has already been standing some time, the supernatant fluid may be removed, and only the lower strata containing the sediment turned into the conical glass, and allowed further to subside. A pipette, consisting of a plain glass-tube drawn nearly to a point, should then be carried to the bottom of the glass with the index finger firmly pressed upon the distal end. When it has reached the bottom, the finger should be raised for a second only, and quickly

returned. In this manner only the lowest drops are obtained, which are mostly likely to contain the casts. A drop of this fluid is allowed to fall into one of the shallow cells, covered with a thin glass cover, and carefully examined with a one-fourth or one-fifth object-glass and the A eye-piece. If these precautions are taken, and two or three slides examined, casts will either be found, or they are absent. Only the beginner need be cautioned against linen and cotton fibre, hair, or portions of deal-wood. More likely are the mucin flakes and cast-like granular aggregations of inorganic and organic matter to mislead.

6. Spermatozoids frequently occur in the sediment of urine of healthy individuals. When abundant, they form a slight flocculent cloud in the urine, but there is generally nothing in the appearance of urine whence their presence may be suspected. They require a power of 400 diameters (one-fifth with the B eye-piece) to show them well, when they may be recognized by the oval head or body and the delicate tail-like prolongation emanating from it. They no longer exhibit their vibratile movement after entering the urine. Their recognition is most interesting in connection with medico-legal cases—cases of suspected rape. Their presence in vaginal mucus soon after coition and in stains upon linen, is easy of demonstration. In the former case a drop of mucus from within the vagina is placed upon a slide, a drop of water added

if necessary, covered with a thin cover and examined with the microscope. In the latter a simple piece of the stained

FIG. 29.

Human spermatozoids. 1. Magnified 350 diameters. 2. 800 diameters. *a*, viewed from the side. *b*, from the front.

linen may be soaked in water or artificial serum in a watch-glass for half an hour or an hour, and the sediment examined. Beale figures (Fig. 74) some filaments of a vegetable nature resembling spermatozoids.

7. FUNGI. Most of the living organisms found in decomposing urine, formerly looked upon as of animal origin, are now acknowledged to be vegetable in their nature, and are generally called fungi.

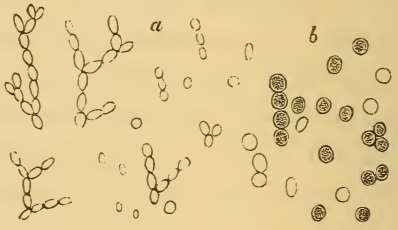
The most frequent among these are bacteria, penicilium glaucum, and the yeast fungus. Sarcinæ are occasionally met with.

1. *Bacteria.* In the refined study which has of late years been given to the subject of fungi, a classification has been made of the minute objects which were formerly called bacteria or vibriones. I take from Hoffmann and Ultzmann the classification of A. Vogel, who makes of them, *a*, the *monad form*, consisting of little trembling points distinguished in their molecular movement from that of inorganic particles, by a progressive motion; *b*, *the staff-shaped* bacteria, which appear as minute lines equalling in length with moderate powers the diameter of a red blood-disk, but mere lines in breadth, sometimes at rest, and sometimes vibrating across the field; *c*, the *vibrio form*, consisting of two or more of the staff-shaped bacteria, adherent end to end, and moving often with great rapidity, sometimes by a spiral movement, and sometimes by vibrating one extremity, as a fish propels itself; *d*, the *leptothrix form* or *chain fungus*, often extending entirely across the field of view, differing from the vibrio forms only by their length, moving seldom, and if at all very slowly; *e*, the *zooglea form*, consisting of heaps of bacteria, mostly punctiform, apparently held together by a gelatinous substance.

2. *The yeast or sugar fungus*, identical with the ordinary yeast fungus, consists in the sporule-stage of transparent oval cells, in their longer diameter about the size of a blood-disk, and of larger spherical cells, granular and nucleated, found in saccharine urine. (Fig. 30.)

According to Hassall, this is a fungus peculiar to saccharine urine, but the small oval cells of the sporule-stage at least cannot be distinguished from the similar stage of

FIG. 30. (After Harley.)



3. *Penicilium glaucum*, which occurs in acid urine with or without albumen or sugar. The sporule-stage furnishes cells very similar to those of the yeast fungus, but later, penicilium by the union of its cells forms thalli or branches which are characteristic. So, too, in the stage of aerial fructification, the penicilium multiplies by simple linear division of cells, while the spores of the sugar fungus fall from a spherical mass not unlike that on the stem of an onion "going to seed."

4. The *sarcina* is a fungus rarely met with in urine. Composed of cubes, it is capable of further separation into smaller cubes. It is similar to, but smaller than the *sarcina ventriculi* of Goodsir.

The germs of these fungi doubtless enter the urine after it has passed from the bladder, in the vast majority of instances, one or the other form being developed

according to the properties the urine may possess. Decomposition seems essential to the presence of the bacteria, but not to the other forms.

8. The elements of morbid growths are seldom met in the urine. Possibly *cells* may be found, and possibly *fragments* of the growth may be broken off and passed with the urine. The former may be suspected to be of morbid origin by their large size, their multinuclear character, the large size of the nuclei, and diversity of the cell-forms. Spindle-cells, it must be remembered, may be derived from the ureter, urethra, and even the bladder, and must not of themselves, therefore, be considered as indicating cancer.

Fragments of cancerous growths which get into the urine are generally from the villous kind, and may show the capillary vessels which make up the villus, with or without the epithelial covering. Fragments, suitable for examination, are sometimes withdrawn with the catheter.

9. Entozoa are seldom found in the urine in this climate. Echinococcus cysts, as well as their hooklets, have been passed in two or three instances recorded. The eggs and ciliated embryos of *Bilharzia hæmatobia* have been found by Dr. John Harley in three patients with the endemic hæmaturia of the Cape of Good Hope, and I had the privilege, through the kindness of my friend, Dr. S. W. Gross, of examining one of the slides containing ova, sent to this country. The parasite itself is found in the vesi-

cal, mesenteric, and portal veins, causing hemorrhages into the intestines, bladder, ureters, and pelvis of the kidney. The ova and parasite are figured by Beale, op., p. 402.

Distoma hæmatobium has been found in the bladder, ureters, and pelvis of the kidney, especially in Egypt.

DIFFERENTIAL DIAGNOSIS OF RENAL DISEASES.

While it is quite impossible to determine with absolute certainty all of the different affections to which the kidneys are liable, by a mere examination of the urine, there is nevertheless an association more or less close of signs with well-determined conditions. With such association it is important that we should be familiar, while we should as well recognize the fact that they are subject to variations and exceptions. If these truths are properly remembered, it is not likely that any one can be led far astray by observing the following:

I. The urine is scanty, dark, "smoke-hued," so long as it remains acid, but becomes red if alkalized. It is highly albuminous. Its specific gravity is not constant, but apt to be high—1025 or above—not from an increase in urea, but from the presence of blood. It contains a variable, but generally large amount of reddish-brown, pulverulent sediment, which, on microscopic examination, is found made up of large epithelial casts and epithelial cylinders, blood-casts, hyaline casts of large diameter, dark-red granular casts, numerous red blood-disks, and free cells, more or less round and nucleated, twice as wide as the blood-disks, cloudy, and more granular

than in health, the granules often obscuring the nucleus. Crystals of uric acid are often present. The chlorides are at first diminished, also the earthy phosphates. Hæmatin, indican, and uric acid are increased.

The patient is dropsical, much swollen about the face, and, if a child, has had scarlet fever, or, if an adult, has been exposed to wet while perspiring.

The disease is *acute nephritis*, scarlatinal nephritis, or acute Bright's disease, and the chances for recovery are many.

II. The urine is pale, and of low specific gravity—1005–15; its quantity, though variable, generally diminished. Albumen is diminished as compared with (I), but is still abundant—one-quarter to one-half the bulk. It deposits an appreciable white sediment, which, by microscopic examination, is found made up of black, highly granular casts, hyaline casts, and casts containing fragments of epithelium; also compound granule-cells (Fig. 24). Probably also there are casts containing a moderate quantity of oil, and perhaps also partially fatty cells. The urea is diminished, the chlorides normal, pigment diminished. There is also œdema, more or less general, which may, however, subside, but the patient has a pale, almost characteristic waxy look. The symptoms have existed more than six weeks.

The disease is probably the large white kidney, a chronic continuation of (I), known also as *chronic tubal*

nephritis, and recovery, though possible, is not likely to occur.

III. The urine presents the same general characters as in the last case, contains rather more albumen, and a more abundant sediment, which is found made up of numerous oil-casts filled with free oil, and oil contained in epithelial cells. There are numerous free fatty cells, and free oil-globules. The urea is diminished.

It is the *true yellow fatty* kidney, which, sometimes at least, originates independently of any acute inflammation of the organ, in drunkards. Dropsy is persistent. The disease is pre-eminently fatal. The patient exhibiting the peculiar cachexia mentioned under (II), will generally perish within the year.

IV. The disease has existed for more than a year, the urine varies in amount, but is at least not so much diminished, and the specific gravity is somewhat higher than in (II). The albumen is diminished, but is still considerable. The urine deposits a more scanty sediment, made up of hyaline casts, some of which contain fragments of epithelial cells, some are partially filled with oil-drops, while some are still highly granular. Compound granule-cells occur, but are less numerous, and there may be some fatty epithelial cells, but the amount of oil, though distinctive, is not very large. The urea is much diminished. There is generally some dropsy, less than in (I), (II), and (III), but more than in (V).

Here the *large white kidney has probably commenced to contract*, but one must be cautious about drawing too sharp a line between these two affections. The prognosis is unfavorable, but the disease may last some time—even years.

V. The urine is increased in amount, correspondingly pale, but, while micturition may be a little more frequent, it may not attract attention. The patient may have to rise once in the night. The specific gravity is little, if at all, diminished—1018–20—while the quantity of albumen is trifling, never exceeds one-quarter, and often is shown by a mere line of opacity in Heller's test. It deposits often no visible sediment, and at all times a trifling one. In this are found delicate hyaline, and finely granular casts, often of small diameter. Some of these contain one or two glistening oil-drops, but very minute. Here are found the casts which are at times almost invisible. The urea is generally slightly diminished.

There is no dropsy. There are often no symptoms whatever connected with the disease. If any, the patient may complain of a weak, tired feeling, and this symptom should suggest an examination of the urine always. The disease may exist for years without the knowledge of the patient, who may or may not be subject to gout. (The urine of gouty patients should be frequently examined.)

The disease is the *chronically contracted* kidney, the interstitial nephritis of the German pathologists. If exposure to cold and fatigue be avoided, the patient's life may be scarcely shortened, and yet he is constantly liable to attacks of uræmia, which may suddenly terminate his life.

VI. The urine is normal in quantity or increased, clear, of low specific gravity, 1015, of a pale, golden color, the color of a dilute urine only, contains considerable albumen, about one-fourth; urea is diminished. There is very little or no sediment visible. Casts are often wanting, and when present are hyaline and waxy, the latter solid-looking, *sometimes* giving the characteristic red reaction of the albuminoid substance when treated with a *watery* solution of iodine and iodide of potassium. Here hyaline casts of large diameter are found, and sometimes within these smaller casts.

There is apt to be dropsy, sometimes persistent, but generally, except towards the termination of the case, amenable to treatment by rest and diuretics. The patient has an enlarged liver or spleen, sometimes persistent diarrhœa; he has had syphilis, or extensive disease of the bones, or has phthisis.

The disease is *albuminoid degeneration of the kidney*, and is incurable, though the patient may live many years.

The above is given as a general guide, and I would

again refer to the fact that there are deviations from the conditions laid down. There are still many points quite disputed in the pathology of the kidney. Thus, the German pathologists contend that there is a constant relation of succession between the acute parenchymatous nephritis, the chronic parenchymatous nephritis (large white kidney), and the contracting stage of the latter, making no distinction between the large white kidney and the fatty kidney. Both, it is true, are fatty kidneys, but while the fat in the former is molecular or granular fat, in the latter it is globular. Although these two may also at times be different stages, the latter being the more advanced, no fact is better determined than that the true fatty kidney *may* originate insidiously without any acute attack.

One more fact must be mentioned in this connection, and this is that although the presence of fatty casts and fatty epithelium are unfavorable symptoms, yet it does not follow that such cases are necessarily fatal. I have, on more than one occasion, found oil-casts in the urine of patients, and yet have also found them to disappear altogether. The circumstances under which this has occurred have been, 1st, where there has been heart disease and kidney disease combined, and there has been some exacerbation of one or both, when the albumen has increased, and oil-casts have made their appearance,

which later, totally disappeared; 2d, where pregnancy has supervened on existing Bright's disease, and oil-casts have been present, which again disappeared after a successful labor.

TO DETERMINE THE COMPOSITION OF URINARY CALCULI

THE qualitative analysis of gravel or calculi is much simpler than is generally supposed. There are but three forms of calculi, which are of at all common occurrence, and which are, therefore, likely to demand analysis. These are *uric acid*, *oxalate of lime*, and the *mixed phosphates*.

1. *Uric acid calculi* are the most common. They are either red or some shade of red, and usually smooth, but may be tuberculated. They leave a mere trace of residue after ignition.

Test. Their nature may be determined by reducing a fragment to powder, and applying the murexid test as described, p. 86.

2. *Oxalate of lime calculi* are frequently met with. They are generally of a dark-brown or dark-gray color, and from their frequently tuberculated surface have been called mulberry calculi. They may, however, also be smooth. Considerable residue remains after ignition. The calculus is soluble in mineral acids without effervescence.

To *test* a calculus suspected to be oxalate of lime, ignite some of the powder on platinum-foil, at a red heat, by which it is reduced to carbonate of lime. If a small

quantity of the resulting powder be placed on a glass slide, covered with a thin cover, and treated with acetic acid, effervescence will be observed with or without the microscope. Or a portion of the original powder may be heated in the blowpipe flame, by which it is reduced to caustic lime, which promptly *blues* reddened litmus-paper.

3. *Calculi of the Mixed Phosphate or Fusible Calculi* are composed of the phosphate of lime and of the triple phosphate of ammonia and magnesia. They form the external layer of many calculi of different composition, and may form entire calculi, but very seldom form the nuclei of other calculi. They are exceedingly brittle, soluble in acids, but insoluble in alkalies.

Test. They may be known by the above properties, and by fusing in the blowpipe flame into a hard enamel.

Few calculi of large size are of the same composition throughout. Oxalate of lime is the most frequent nucleus, but uric acid may also serve as a nucleus, but phosphates, as stated, almost never. Small collections of organic matter, as blood-clots, frequently form nuclei, and may often be recognized by the odor of ammonia on ignition. It is not uncommon to find calculi made up of concentric layers of different composition.

MODE OF RECORDING AN EXAMINATION.

To systematize and facilitate the work of urine examinations, forms of record have been devised by those

working in the subject. I have for some time used, with great convenience, that suggested by Prof. Austin Flint, Jr., in his manual on the Chemical Examination of Urine, but for ordinary use in hospital and private practice that of Heller recommends itself for its economy and readiness.

Heller recommends that an ordinary half-sheet of letter paper be folded in four, and marked as indicated below:

PHYSICAL PROPERTIES.

Quantity in twenty-four hours.

Color and reaction.

Sp. gr.. Quantity of sediment.

NORMAL CONSTITUENTS.

Uph. (Urophain.)	Cl. (Chlorides.)
Ux. (Uroxanthin.)	Eph. (Earthy phosphates.)
$\overline{U}$. (Urea.)	Alkaline phosphates.
$\overline{\overline{U}}$. (Uric acid.)	Sulphates.

ABNORMAL CONSTITUENTS IN SOLUTION.

SEDIMENT.

Abbreviations for the important constituents are used as shown, and the sign "+" for *increased*, the sign "—" for *diminished*, and the letter "n" for *normal*. For *great* increase or *great* diminution, "gr. +" and "gr. —" may be used, and for *slight* increase or *slight* diminution, "sl. +" or "sl. —."

Let us suppose an examination to have been made, with the following results. The word "indican," "*ind.*" is preferred for "uroxanthin," and substituted.

PHYSICAL PROPERTIES.

Quantity in twenty-four hours, 500 c.c.

Color, very pale yellow. Reaction, acid.

Sp. gr., 1005. Sediment, moderate.

NORMAL CONSTITUENTS.

Uph.	gr. —	Cl.	n.
Ind.	sl. +	Eph.	—
$\frac{+}{U}$ / $\frac{-}{U}$	gr. —	Aph. / Sph.	—

ABNORMAL CONSTITUENTS IN SOLUTION.

Albumen, 50 per cent.

SEDIMENT.

Numerous oil-casts, free fatty cells, and free oil-globules.

Diagnosis—Fatty kidney.

TABLES

For Reducing the Metric or French System into the English, and vice versa, as far as required in Urinary Analysis.

Grammes to Grains.		Grains to Milligrammes.	
1 =	15.43 (+ .0022)	1 =	64.8 (— .000425)
2 =	30.86	2 =	129.6
3 =	46 29	3 =	194.4
4 =	61.72	4 =	259.2
5 =	77.15	5 =	324.0
6 =	92.58	6 =	388 8
7 =	108.01	7 =	453.6
8 =	123.44	8 =	518.4
9 =	138.87	9 =	583.2

Cubic Centimetres to Minims.		Minims to Cubic Centimetres.	
1 =	16.2 (+ .0293)	1 =	.0616
2 =	32.4	2 =	.1232
3 =	48.6	3 =	.1848
4 =	64.8	4 =	.2464
5 =	81.0	5 =	.3080
6 =	97.2	6 =	.3696
7 =	113.4	7 =	.4312
8 =	129.6	8 =	.4928
9 =	145.8	9 =	.5544

Cubic Centimetres to Fluid Drachms.		Fluid Drachms to Cubic Centimetres.	
1 =	.27 (+ .0005)	1 =	3.7
2 =	.54	2 =	7.4
3 =	.81	3 =	11.1
4 =	1.08	4 =	14.8
5 =	1.35	5 =	18.5
6 =	1.62	6 =	22.2
7 =	1.89	7 =	25.9
8 =	2.16	8 =	29.6
9 =	2.43	9 =	33.3

Litres to Fluid Ounces.			Fluid Ounces to Cubic Centimetres.		
1	=	33.8 (+ .011)	1	=	30 (— .4238)
2	=	67.6	2	=	60
3	=	101.4	3	=	90
4	=	135.2	4	=	120
5	=	169.0	5	=	150
6	=	202.8	6	=	180
7	=	236.6	7	=	210
8	=	270.4	8	=	240
9	=	304.2	9	=	270

Litres to Pints.			Pints to Litres.		
1	=	2 1 (+ .013188)	1	=	.473 (+ .00022)
2	=	4.2	2	=	.946
3	=	6.3	3	=	1.419
4	=	8.4	4	=	1.892
5	=	10 5	5	=	2 365
6	=	12.6	6	=	2.838
7	=	14.7	7	=	3.311
8	=	16.8	8	=	3.784
9	=	18.9	9	=	4.257

Inches to Millimetres.			Millimetres to Inches.		
1	=	25.4 (+ .00005)	1	=	.03937
2	=	50.8	2	=	.07874
3	=	76.2	3	=	.11811
4	=	101.6	4	=	.15748
5	=	127.0	5	=	.19685
6	=	152.4	6	=	.23622
7	=	177.8	7	=	.27559
8	=	193.2	8	=	.31496
9	=	228.6	9	=	.35433

Metres to Feet.			Feet to Metres.		
1	=	3 28	1	=	.3048 (+ .0000005)
2	=	6.56	2	=	.6096
3	=	9.84	3	=	.9144
4	=	13.12	4	=	1.2192
5	=	16.40	5	=	1.5240
6	=	19.68	6	=	1.8288
7	=	22 96	7	=	2.1336
8	=	26.24	8	=	2.4384
9	=	29.52	9	=	2 7432

To Convert Degrees of Fahrenheit's Thermometer to Centigrade, and vice versa.

Centigrade to Fahrenheit.			Fahrenheit to Centigrade.		
1	=	1.8	1	=	.555 (+ .000555)
2	=	3.6	2	=	1.110
3	=	5.4	3	=	1.665
4	=	7.2	4	=	2.220
5	=	9.0	5	=	2.775
6	=	10.8	6	=	3.330
7	=	12.6	7	=	3.885
8	=	14 4	8	=	4 440
9	=	16 2	9	=	4.995

To use this table, convert the given number of degrees Centigrade into degrees Fahrenheit, and add 32°.

To use this table, subtract 32° from the given number of degrees Fahrenheit, and convert the remainder into degrees Centigrade.

(*From Dr. Craig's Decimal System.*)

ADDENDA.

NOTE TO PAGE 41.

The carbolic acid test in the alcoholic and acetic acid mixture recommended by Mehu, has not been satisfactory in my hands, the milkiness which occurs when carbolic acid is mixed with water or non-albuminous urine obscuring the results. With the mixture of equal parts of acetic and carbolic acids, recommended in a recent number (September 26, 1874) of the *London Medical Times and Gazette*, I have not yet had sufficient experience.

It might also be said with regard to the method there described of applying Heller's test, of first placing a suitable quantity of nitric acid into a test-tube, and then allowing the urine to fall gently upon it so as to "overlay" it,—that I have habitually used it as well as the method described in the text, which is more precisely Heller's, and have found no practical difference in results.

NOTE ON A CONVENIENT METHOD OF TRANSPORTING URINE, ESPECIALLY IN WARM WEATHER, FOR A DISTANCE.

While returning the last "revise" to the printer, the following note was received from my friend Dr. W. W. Keen, whose experiments with chloral as a preservative are already well known to the profession:

"I have been testing the preservative properties of chloral, and also its possible erroneous conclusions. I find it will preserve urine for some weeks even, and give the chemical tests for albumen and sugar, and preserve for microscopical examination spermatozoids, epithelium (tube-casts I have yet not tried), phosphates, and uric acid, etc. Apparently it may prove of great value therefore for the examination of the urine at a distance, whether in time or place."

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